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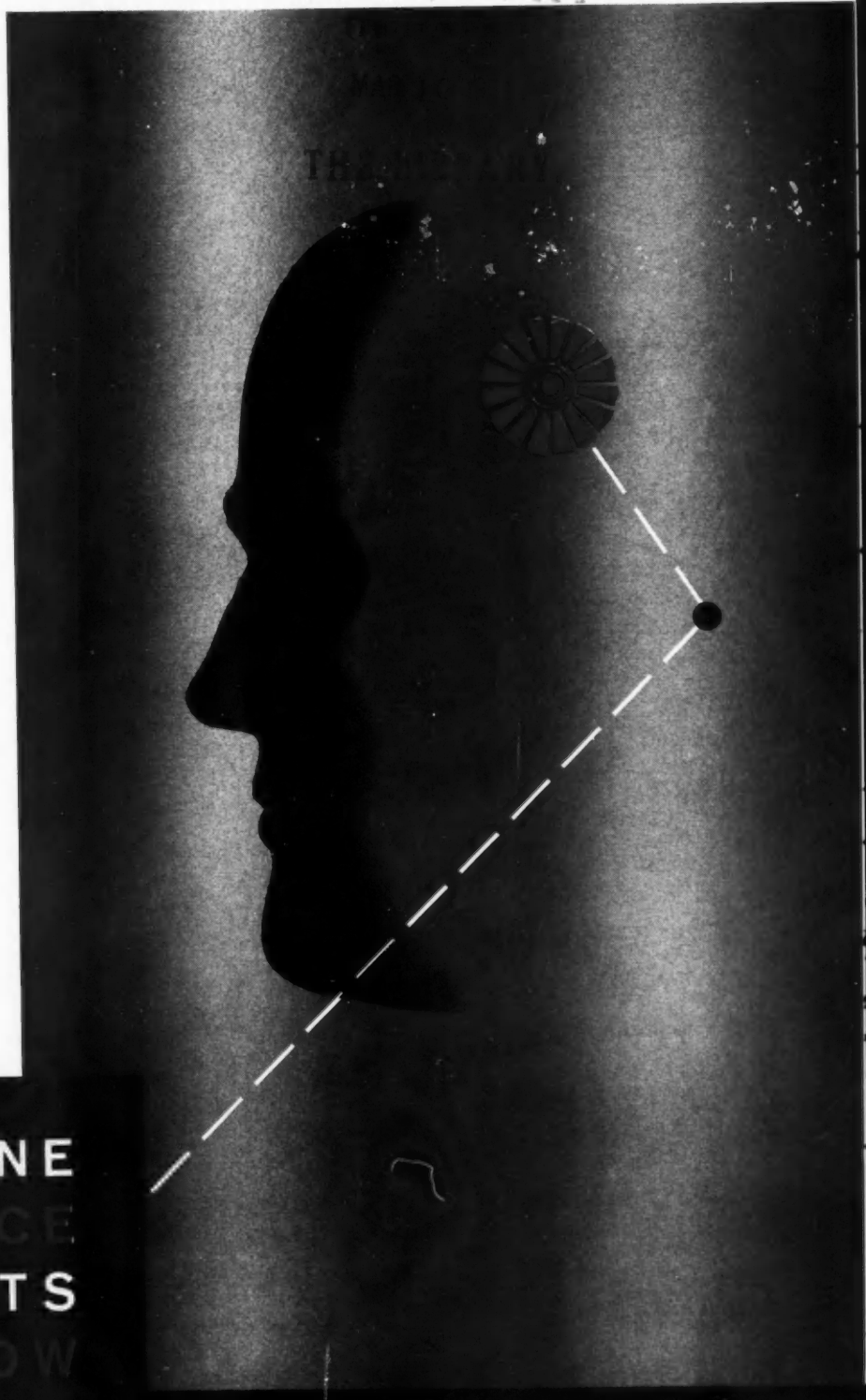
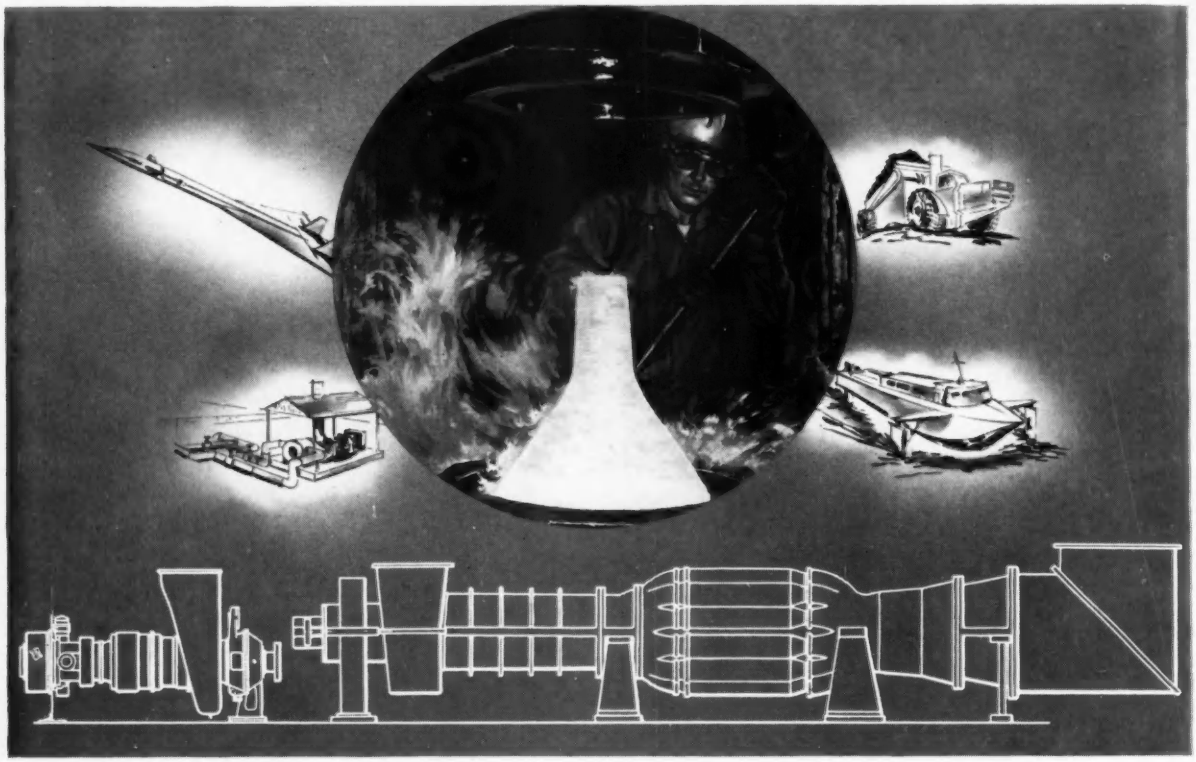
March-April 1961

GAS TURBINE

THE UNIVERSITY



GAS TURBINE CONFERENCE & PRODUCTS SHOW



Turbine Forgings Unlimited

Few prime power sources depend so completely on part integrity for reliable performance as the gas turbine. Its extremes of temperature, rotating speed and imposed stress demand a level of metallurgical soundness available only in closed impression die forgings.

This is as true of workaday turbines—serving in the growing list of stationary, propulsion and auxiliary power applications—as for the most critical military designs. In each, dependability stems from component stamina.

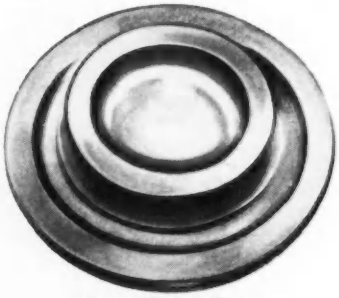
No other process approaches forging for optimum development of required properties, refinement in structure and precise control of flow characteristics. None combines high ultimate strength with comparable ductility to combat severe and sustained shock load.

Experienced leader in Automotive, Aircraft, Missile, Nuclear and Turbine fields, Wyman-Gordon is well prepared to meet your complete forging requirements. For one turbine forging—or thousands—contact Product Manager, Turbine Applications.

EST. 1883

Length 22″; weight, 190 lb.; material, nickel-base, high-temperature alloy (Cutaway shows uniform wall)

Diameter, 10″; weight, 45 lb.; material, Inconel X



Diameter, 29″; weight, 1000 lb.; material, Astroloy

Length, 18″; weight, 10 lb.; material, ironbase, high temperature alloy

Length, 22″; weight, 45 lb.; material, high-strength, nickel-base alloy

WYMAN-GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS WORCESTER MASSACHUSETTS DETROIT MICHIGAN

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For more information write in No. 1

JET POWER COMES DOWN TO EARTH

Pratt & Whitney Aircraft has now successfully converted 12 million hours of jet reliability into a stationary 10,500 h.p. application for the gas industry. Coming soon...for the electric utility industry...a complete 10,000 kw. powerplant package for peaking, stand-by and end-of-line power generation.

Visit us at our display during the Gas Turbine Power Conference, Shoreham Hotel, Washington, D.C. We'll be happy to supply you with complete information on these and other new, economical ideas for industrial gas turbine applications.

UNITED AIRCRAFT CORPORATION

Pratt & Whitney Aircraft Division

EAST HARTFORD, CONNECTICUT

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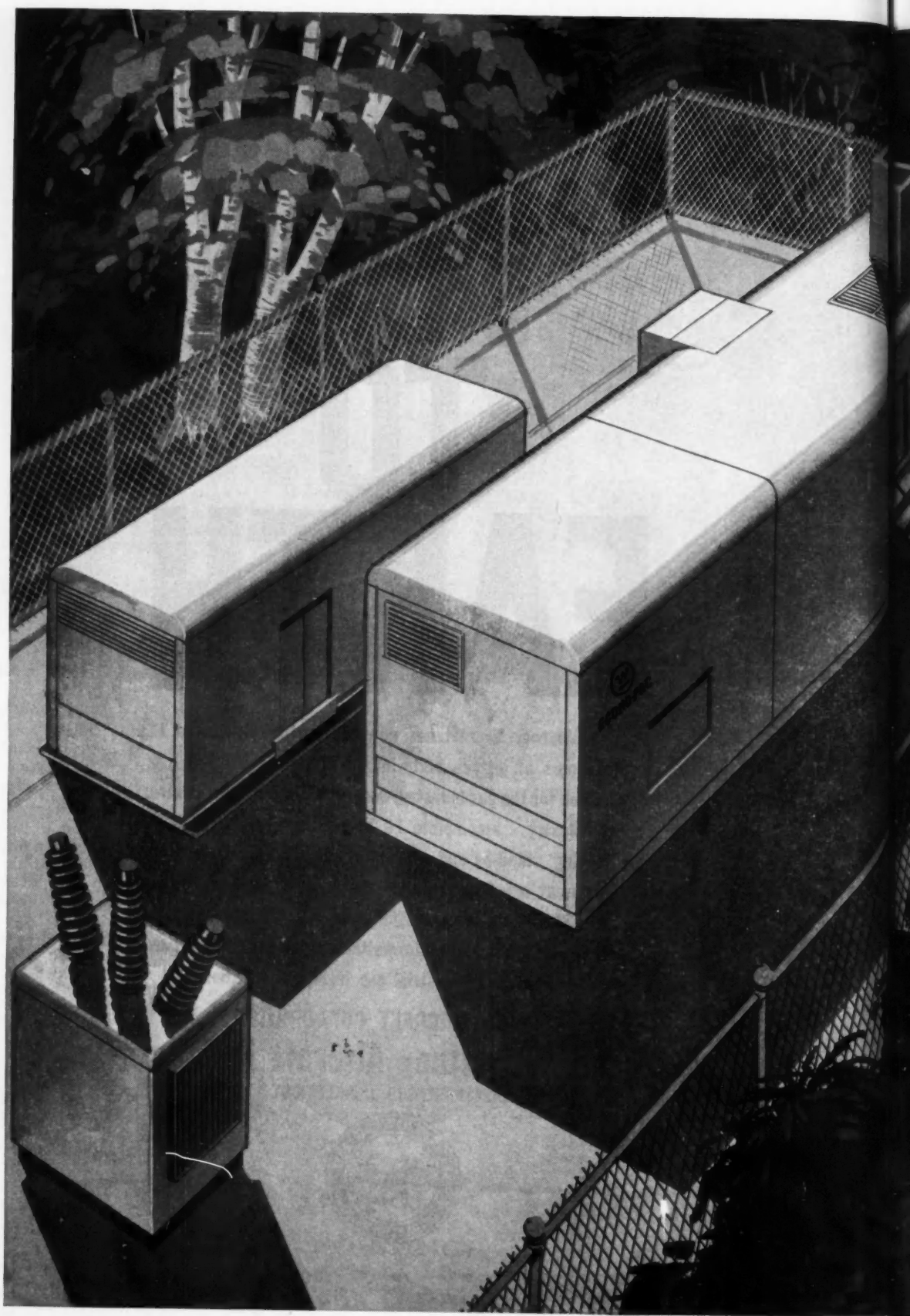


New Westinghouse ECONO-PAC Gas Turbine

3000, 7000 or 12,000 kw
a self-contained plant for peaking, reserve and emergency
cuts installed costs to $80 and $100/kw

Here is another new measure of economy in power generation—the Westinghouse ECONO-PAC* gas turbine power plant. The ECONO-PAC is completely integrated when delivered, ready for immediate use.

The complete installed cost of ECONO-PAC is as low as $80/kw, based on winter operation, or $100/kw for summer operation. These costs are decidedly lower than those for conventional plants of the same or even larger sizes. And, the ECONO-PAC features portability—goes as a unit to location where needed as loads change.

The Westinghouse ECONO-PAC gives these definite advantages:

Meets wide range of generating problems . . . peaking, reserve capacity or emergency service.

Fast installation . . . only fuel, electrical connections and a flat concrete slab foundation (about three feet thick) are needed to put ECONO-PAC into operation; means two weeks or less from arrival on site to start-up.

Fully automatic . . . unattended operation.

Portable component construction . . . complete unit can be relocated quickly to meet changing system loads.

Full capacity, dual fuel operation . . . uses the most economical fuel without loss of rated output.

Dry plant operation . . . radiator coolers eliminate cooling water requirements.

Increased capability at low ambient temperature . . . at 40°F, plant output is increased by 25%.

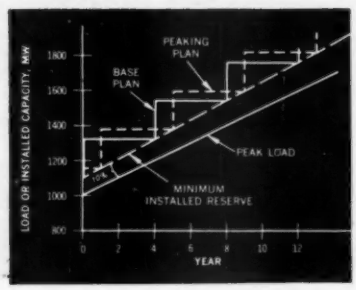
Quiet . . . acceptable in residential areas.

Call your Westinghouse representative for details on ECONO-PAC—the distinctive, low-cost power package. You can be sure . . . if it's Westinghouse.

*Trade-Mark
J-50618

Westinghouse

WESTINGHOUSE POWERCASTING STUDY REVEALS ECONOMY OF GAS TURBINE APPLICATION

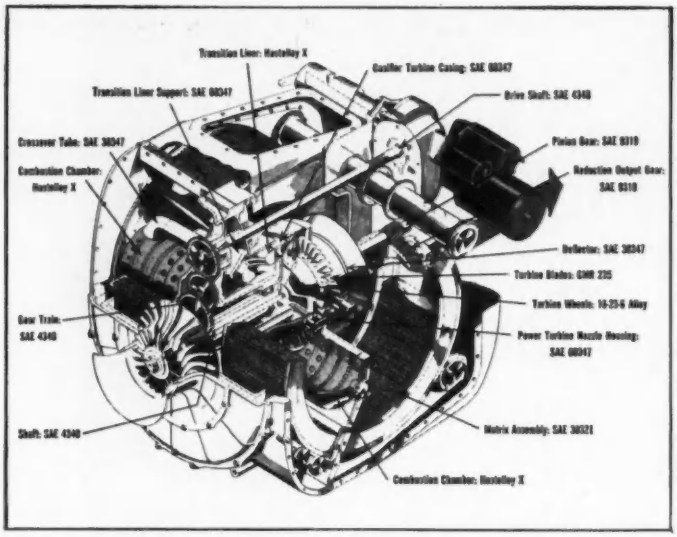


Westinghouse conducted a Powercasting study recently for a utility working on a 4-year cycle of adding generating equipment. The study showed that addition of gas turbine plants permitted postponement of buying base-load generators for a year. This would make possible a potential net capital saving of over $800,000 over a 13-year period.

COMPLETE RANGE

Westinghouse offers a complete line of gas turbine power plants—ranging from 3 to 150 mw—engineered for your particular requirements.

For more information write in No. 3


Transition Liner: Hastelloy X
Gasifier Turbine Casing: SAE 80347
Transition Liner Support: SAE 80347
Drive Shaft: SAE 4340
Crossover Tube: SAE 30347
Pinion Gear: SAE 8310
Combustion Chamber: Hastelloy X
Reduction Output Gear: SAE 8310
Deflector: SAE 30347
Turbine Blades: GMR 235
Turbine Wheels: 16-25-6 Alloy
Gear Train: SAE 4340
Power Turbine Nozzle Housing: SAE 80347
Shaft: SAE 4340
Matrix Assembly: SAE 30321
Combustion Chamber: Hastelloy X

Ore truck tests durability of nickel alloy parts in new gas turbine

225-hp Allison "Whirlfire" uses 8 nickel alloys for critical components. These alloys were selected for this truck engine to provide the optimum mechanical properties and to resist the higher temperatures met in delivering 70% more power per pound than a comparable piston engine.

"Whirlfire"—a prototype gas turbine developed by Allison Division of General Motors—hauls 32-ton loads of ore on winding roads with 8% grade, in experimental use at Inco's open-pit mine in Sudbury, Ontario. With 16 vital parts made from nickel alloys to resist heat or mechanical stress, "Whirlfire" delivers more usable horsepower than reciprocating engine.

See other new developments at the Inco exhibit, Booth 22, Gas Turbine Conference, March 5-9.

INCO TRADE MARK

Inco Nickel

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

For more information write in No. 4

GAS TURBINE

VOLUME 2, No. 2, March-April, 1961

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INDUSTRIAL GAS TURBINES

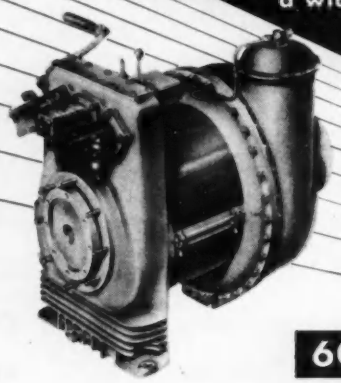
SNECMA taking advantage of the valuable experience it has acquired in the turbo-jet engine field, has designed and is now manufacturing industrial gas turbines ranging from 60 to 100 HP and from 9,000 to 14,000 HP for various uses, and in particular:

- Electrical power stations
- Compressing plants for gas or oil
- Pumping stations
- Boat engines
- Power units for electrical generators, etc...

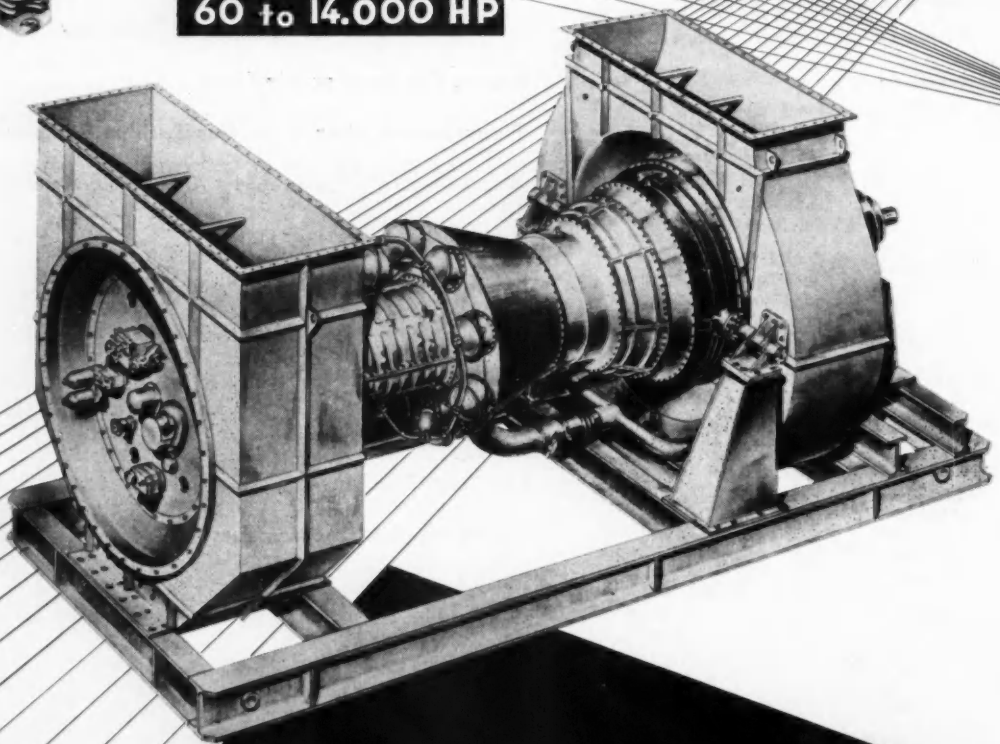
All the above gas turbines made by SNECMA operate with a wide range of fuels, their outstanding features being:

- Endurance
- Lightness
- Ease of maintenance, etc...

Moreover, any engineering project in connection with these gas turbines can be handled by SNECMA.



60 to 14.000 HP



SNECMA

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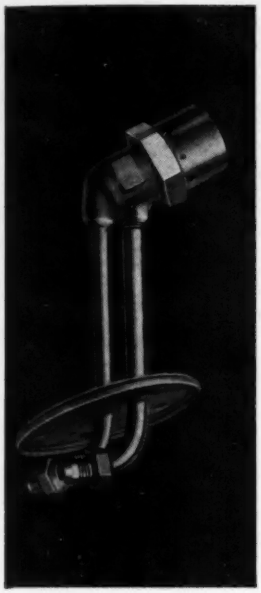
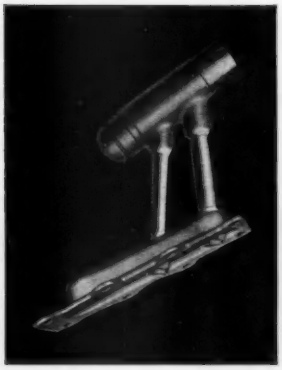
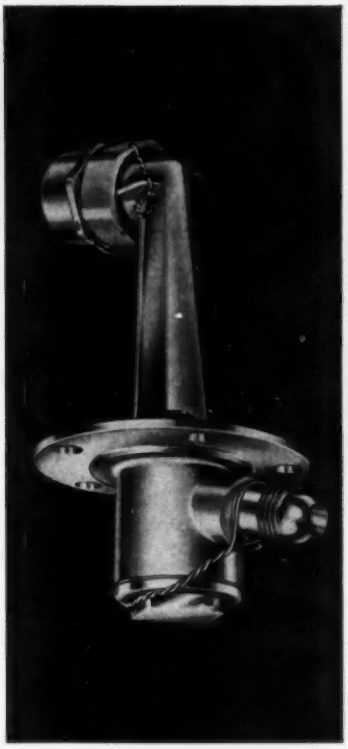
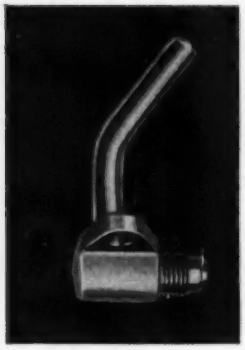








PROVED BENDIX EXPERIENCE CAN SOLVE YOUR FUEL NOZZLE PROBLEMS, TOO!

Bendix is exceptionally well prepared to serve as a member of your turbine design team. Our background includes 9 years of designing and producing precision fuel nozzles for jet and ramjet engines. These dependable nozzles are on engines powering jet aircraft all the way from the T-37A to the B-58.

Bendix designs solve such formidable problems as faster cold starting on the ground, and instant re-starting should flameouts occur in flight.

Bendix also works closely with major automotive manufacturers in research and experimental programs, designing fuel nozzles for gas turbines.

Our wealth of design data is available to you. Bring your fuel nozzle problems to Bendix, as many leading engine manufacturers do. Write for complete information today.

VISIT BENDIX BOOTH #21 AT GAS TURBINE SHOW, SHOREHAM HOTEL, WASHINGTON, D. C., MARCH 6-9

Bendix-Elmira
Eclipse Machine Division
Elmira, New York

THE Bendix CORPORATION

For more information write in No. 6

Auxiliary Gas Turbines becoming a prime power source for industry

Helmut Schelp, chief engineer, AiResearch Manufacturing Division of Arizona, Phoenix, surrounded by typical gas turbines now in production ranging in size from 30 to 850 hp. Clockwise from the top: GTC 85-28 GTCP 105 · GTP 70-6 · GTP 30-1 · GTP 70-10 · GTU 85-2.

AiResearch Gas Turbine Engines, the most widely used power source for the starting, air conditioning, cooling and heating of jet aircraft, now are becoming a prime power source for industry.

Easier to maintain because of few moving parts, these lightweight gas turbine engines develop more horsepower per pound of weight and size than any other engine. Achieving their greatest efficiency at maximum speeds, they run on almost any fuel and start immediately in any weather.

Future prime power applications of AiResearch gas turbines for industry: earthmoving equipment; small independent generator plants; marine use; helicopters and small conventional aircraft; emergency power plants; air conditioning, heating and refrigeration; atomic energy; compressor sets and air drilling for gas gathering.

First to design and develop a successful small gas turbine engine, Garrett is the world's largest manufacturer of lightweight turbomachinery — having delivered more than 200,000 units, including 9000 gas turbines of all types ranging from 30 to 850 hp. Through its AiResearch Manufacturing Divisions, The Garrett Corporation is now offering this experience to all industry.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

LOS ANGELES 45, CALIFORNIA • PHOENIX, ARIZONA

OTHER DIVISIONS AND SUBSIDIARIES: AIRSUPPLY-AERO ENGINEERING • AIRESEARCH AVIATION SERVICE • GARRETT SUPPLY • AIR CRUISERS AIRESEARCH INDUSTRIAL • GARRETT MANUFACTURING LIMITED • MARWEDEL • GARRETT INTERNATIONAL S.A. • GARRETT (JAPAN) LIMITED

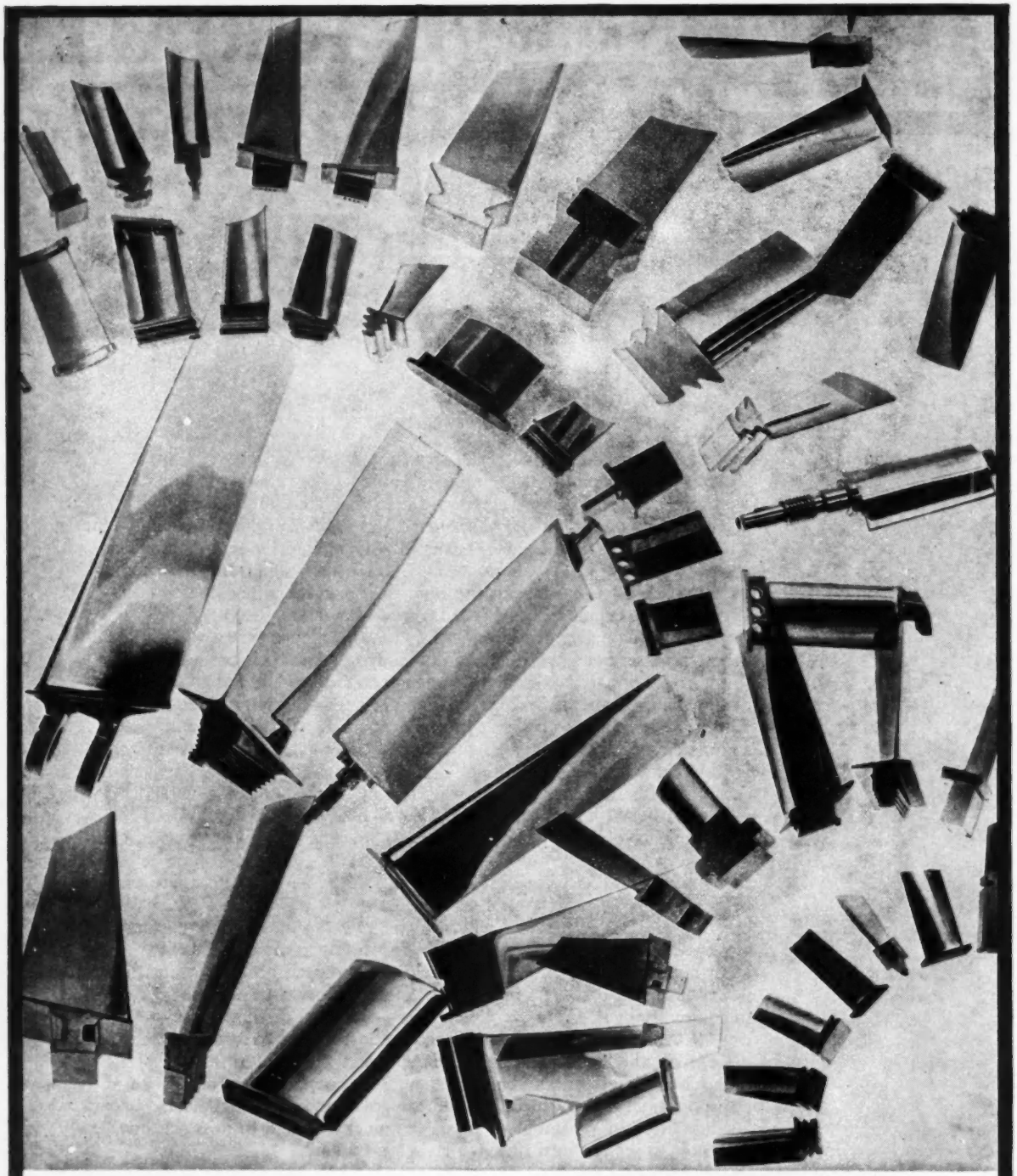
For more information write in No. 7

GT EDITORIALLY SPEAKING

Gas Turbine Show Back in Washington

In 1944 at Tulsa, the Gas Turbine Coordinating Committee of the ASME was formed. It consisted of ten top gas turbine engineers from this country. This soon expanded to 50, including members from various parts of the world. In just three years, interest was such that the Committee achieved divisional status and became ASME's Gas Turbine Power Division. Then in 1956 the GTPD held its first divisional Gas Turbine Conference and Product Show in Washington, D. C. This was a significant step; some older ASME Divisions have yet to hold their own individual conferences. It showed the extent to which the Division was serving the needs of gas turbine engineers. The Product Show was evidence that a gas turbine industry was in being, with companies ready to show their products and ideas. Five Annual Gas Turbine Conferences and Product Shows have demonstrated that this is THE meeting place for the gas turbine industry. They have been a good example of proper blending of technical and commercial interests—interests that must be mutually supporting for industry growth. The 6th Annual Conference and Product Show will be no exception. It's the place to learn what's going on, both technically and commercially. Although expected to be well attended, it will still be small enough to preserve the cooperative, congenial atmosphere of previous occasions when the gas turbine fraternity gathered. At this meeting the Department of Defense is Co-Sponsor and, thanks to them, there will be operating exhibits at the Pentagon. The industry is well past the talking stage; those attending will see actual gas turbines pumping water and operating autos, trucks and tanks. This is only a token of today's many applications ranging from propelling high-speed boats to generating power at missile bases and in central stations; from military aircraft to commercial jets. From every viewpoint—technical or commercial—this 6th Annual Conference and Product Show should be attended. It is the place to get the "feel" of the gas turbine industry and the turbines themselves. You'll see why big power in a small package is revolutionizing transportation, power generation and the power industry in general. See it yourself in Washington. If you're unlucky enough to miss this one, plan now to see the next one. It's Houston in 1962.

R. Tom Sawyer



CENTRAX

NEWTON ABBOT
DEVON ENGLAND

AMERICAN SALES OFFICE
938 PARK SQ. BLDG.
BOSTON 16, MASS.

MANUFACTURERS OF PRECISION MACHINED COMPRESSOR AND TURBINE BLADES.

For more information write in No. 8

GT HOT LINE

FIRST JET ENGINE-POWERED GENERATOR SERVES HOMES AND INDUSTRY . . .

The nation's first jet engine-powered electrical generator to serve homes and industry will be installed in Hartford, Connecticut . . . This pioneering step was announced jointly by Raymond A. Gibson, president, Hartford Electric Light Company (HELCO) and L. C. Mallet, general manager, Pratt & Whitney Aircraft Division, United Aircraft Corporation . . . A modified J-57 engine driving a power turbine will be coupled to a 3600-rpm generator, the complete package weighing only 25,000 pounds.

MITSUI SHIPBUILDING TESTS CLOSED CYCLE PLANT . . .

Closed cycle 10,000-hp plant for a naval vessel is operating on the test stand at the Mitsui works . . . Designed by Escher-Wyss, it was built by Mitsui in Japan.

"THE IDEAL FUEL" . . .

American Gas Association press conference January 26th emphasized use of "the ideal fuel" for gas turbines. Among the host of speakers D. Dana Price of Golemon & Rolfe discussed a gas turbine package unit for producing light (840 cycles), heat and air conditioning in modern schools and similar buildings at a definite savings compared to present practice . . . AGA has already discussed this approach with many gas turbine manufacturers . . . belief is that it looks like a new field for the gas turbine.

ELECTRICITY BOARD ORDERS ANOTHER BRISTOL SIDDELEY TURBO GENERATOR . . .

A third 3MW turbo generator set has been ordered from Bristol Siddeley by South Western Electricity Board in England for robot power station duty. These stations are the first of their kind in the world to go into service . . . like two similar sets already in use, this unmanned "pocket" power station will be fully automatic, will operate under remote control by telephone from South Western's headquarters in Bristol . . . Prime mover of these sets is a modified version of the Bristol Siddeley Proteus turboprop aero engine . . . advantages of this equipment include low capital cost, fully automatic operation with remote control, instant readiness at all times (which is equivalent to spinning reserve) and high reliability.

EXHIBITS AT THE PENTAGON . . .

Sixth annual gas turbine power conference and exhibit in Washington will include a few very interesting exhibits . . . U.S. Army is showing LARC-5 with Allison GMT-305 gas turbine; 4-wheel rubber-tired tractor with GMT-305; T95 heavy-duty tank with Solar Saturn . . . U.S. Navy is showing one-man YRON-Gyrodyne helicopter with Solar T62 Titan turbine; 28-foot personnel boat with Boeing gas turbine; a ground start cart; a hydrofoil boat, Sea Wings, with GE 720 turbine; a T45 Mars 500-gpm pump; Clark Bros. 5000-Kw railroad mobile power plant . . . Chrysler is showing both a gas turbine driven truck and car . . . Ford is showing a tiltcab with their 704 turbine . . . Garrett has a flyaway pod GTCP-85 aircraft ground support set; a GTC-85 aircraft starting-air and air-conditioning truck . . . Solar is showing its T62 Titan portable hand-started generator set; the T45 Mars portable hand-started 500-gpm water pump.

GT INDUSTRY NEWS

Upping the Horses

An 82-ft Coast Guard patrol boat will be powered by twin Solar Saturn gas turbine engines under terms of a new contract. The two Solar Saturns will give the boat a 2200-hp propulsion system. Current boats of this type are powered by twin 600-hp diesel power plants.

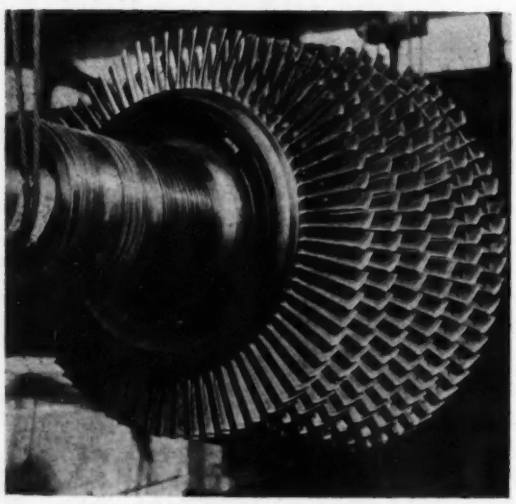
Report on Reliability

Among the exhibits at ASME's Gas Turbine Convention at Washington is a Brown Boveri turbine rotor, displayed in testimony to reliability of gas turbines in very heavy-duty operation.

This particular rotor (shown below) was installed in a 1650-kW turbine at Pertigalete Cement Works at Caracas, where it logged 14,700-hours in base load operation burning fuel oil of high vanadium content. It received only routine water washing; showed no noticeable wear.

This was one of two identically-rated gas turbines placed in service in the fall of 1949, despite misgivings about the dust-filled atmosphere surrounding the cement mill and the fact that heavy oil was to be used as fuel. However, after 3½ years of base load service not a single outage had been recorded due to unexpected failure of the sets.

Rotor at Gas Turbine Show

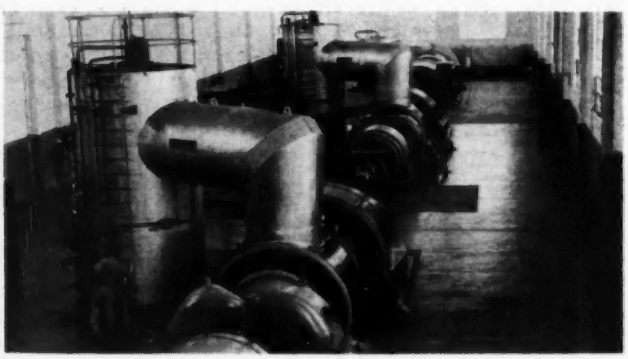


With performance as recommendation, in 1953 Pertigalete placed in service a third gas turbine unit, rated 5000-kW. As of January 1961, #3 had logged 53,000 operating hours, while units #1 and #2 had been placed on standby.

A second 5000-kW unit was installed in 1955. By now, air filter design was such that the original 3000-hour cleaning schedule could safely be increased to 8000-hours. The first inspection of unit #4 took place after 27,000-hours of operation, showing blading in perfect condition. To date, unit #4 has logged 41,000-hours of base load operation.

Covering the period 1951-1959, average maintenance costs were established. According to a certified customer report, maintenance reports for the four engines were:

Total generated hours, million kWh	205.4
Total operating hours	113,650
Total Maintenance costs:	
Replacement Parts	0.00188 cts./kWh
Labor	0.00425 cts./kWh
Total Cost	0.00613 cts./kWh
Lube oil consumption	virtually negligible



Due to high power demand, unit #3 was operated during its first two years at a utilization factors of 96.5%. Availability reached 99.75% despite bad air conditions, heavy loading and loading swings ± 1500-hp. This record led the company to place a fifth, a 6000 kW turbine unit in operation, now in service 2000-hours. (Shown above, two 5000-kW units and the new 6000-kW unit).

Gas Turbine Nomogram Is Aid for Engineer

The following is an excerpt from a letter to R. Tom Sawyer, consulting editor, announcing the availability of the Kreitner Nomogram, a valuable aid for the gas turbine engineer:

"The Kreitner Nomogram does the same—and even more—for the Gas Turbine engineer that the Mollier Diagram does for the Steam Turbine expert.

"I can report that the nomogram is being used by those manufacturers who appreciate amongst its many merits, speed. A computor may do the calculating parts in some micro-seconds, but firstly it must be available; secondly, the setting-up of the problem takes too long for project work.

"The scales of the actual nomogram permit reading down to about one BTU, which is sufficient for most purposes except final design.

"The actual nomograms are on strong, stable paper; the scales are made very exactly from an engraved steel plate.

"I act as publisher and can fill orders accompanied by check or postal order if the order is from an individual. The text of explanation is being sold together with a block of fifty nomograms, all in a durable envelope, for $6.00 excl. postage."

F. Nettel
501-5th Ave.
New York 17, N. Y.

Sikorsky 'Copter for Japan

The Fuji Airlines Company, Ltd., of Tokyo, has ordered a Sikorsky S-62 turbine-powered helicopter for commercial operations in Japan, it was announced by Lee S. Johnson, Sikorsky general manager. The order was placed by Mitsubishi Shoji Kaisha, Ltd., the Sikorsky representative in Japan.

Turbine-Powered 'Copters in Scheduled Bay-Area Service

A new corporation, San Francisco Oakland Helicopter Airlines, will inaugurate scheduled passenger service in the Bay area starting April 1. M. F. Bagan, president of the new company, made the announcement that the airline will operate turbine-powered Sikorsky S-62 amphibious helicopters.

Controls for the "Hot" Ones

Hamilton Standard have their controls on the following turbines, over 25,000 of which have been built to power a great many of the nation's leading military and commercial aircraft: PT-6, JTFD-12, T-55, T-58, T-64, T-72, T-74, J-52, J-57, J-58, J-60, J-69, J-75, J-79 and the P&WA natural gas pumper J-57.

"The Missile with a man in it."

General Electric's Large Jet Engine Department has begun shipment of J79-11A turbojet engines for the Japanese Government's F-104 Super Starfighters. Under the U. S.-Japan Mutual Security Program, J79 engines will be delivered to Japan over the next two years.

"Entirely Smooth" Sailing

Flight testing of a new AiResearch ground support pod being delivered to the Navy has been successfully completed at the McDonnell Aircraft Company, St. Louis. An F4H aircraft was used. Flights above mach. 96 were reported "entirely smooth."

Lycoming T53 Overhaul Time Increased to 500 Hours

This is the longest period for any small military shaft-turbine. Increase by Army and Air Force was granted after accumulation of more than 60,850 hours of T53 running time, of which 43,649 have been in service.

Another "Milestone"

A nine-month program to flight test General Electric's T64-4 turboprop engine in de Havilland's DHC-4 Caribou was announced by Ed Woll, project manager. Tests will get underway in May 1961 and continue through the remainder of the year.

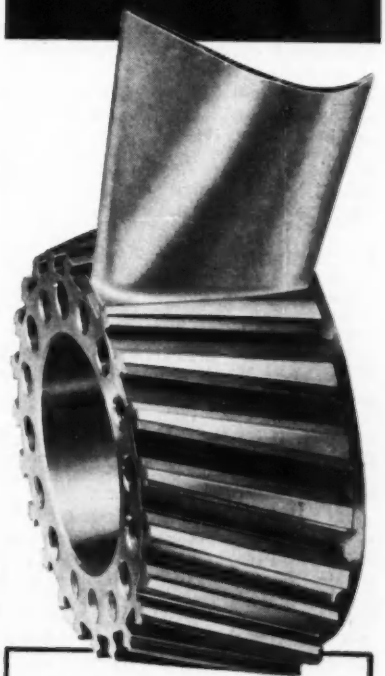
G. E.—Sud Caravelle

Installation of General Electric aft-fan engines on the company's Sud Caravelle jetliner was completed on schedule. The plane is now making test flights with the CJ-805-23C engines.

(Continued next page)

PRECISION Turbine Components

Creative engineering, experience and specialized production facilities at Poly Industries assure the highest degree of precision in manufacturing gas turbine components. Complete facilities for experimental or high production quantities of turbine blades, vanes, wheels and nozzles. Techniques for machining and forming with the toughest alloys of exotic metals are a specialty of Poly Industries.



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For more information write in No. 9

GT CONTRACTS PROCUREMENTS

Some major gas turbine procurements initiated and contracts awarded during recent months by various agencies of the U.S. Government are listed. This material is from the U.S. Department of Commerce publication "Synopsis of U.S. Government Proposed Procurement, Sales and Contract Awards."

• Bureau of Naval Weapons, Washington 25, D.C. 65 Air Turbine Starters in accord with Spec MIL-S-19557A(Aer) and Amd No. 1 thereto. NOw 60-0344-f—$122,720—Bendix Aviation Corp., (Utica Div.), Utica, N. Y.

• Bureau of Naval Weapons, Washington 25, D. C. "Services and materials to rebuild engines, overhaul engines for development testing. NOw 60-0756-d"—$202,360—General Electric Co., Small Aircraft Engine Dept., Lynn, Mass.

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio. "J79-GE-5B Engines, Ground Support Equipment with related Spare Parts and data. (Installations and Spares for B-58A Aircraft) Contract AF 33(600)41952"—127 ea—$22,677,000—General Electric Co., Flight Propulsion Div., Cincinnati, Ohio.

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio. "T53-L-3 Turbo-Prop Aircraft Engines, 30 each; T53-L-5 Shaft-Turbine Aircraft Engines, 139 each, Data and Summary Bill of Materials. (For the Army AO-1 and Hu-1B Aircraft Program) Contract AF 33(600)42060, dated 24 August 1960"—$8,613,613—AVCO Corp., Lycoming Div., Stratford, Conn.

• AMC Aeronautical Systems Center, Wright-Patterson, AFB, Ohio. "T56-A-8 Turbo-prop aircraft engines. (Installations and Spare Support of the Navy W2F-1 Aircraft), 12 ea; T56-A-7 Turbo-prop Engines, (Installations and Spare Support for C-130B and SC-130B Aircraft), 214 ea. Supplemental Agreement No. 1 to Contract A 33(600)41738" —$19,464,200—Allison Division, GMC, Indianapolis, Ind. (Supplement to $25,153,000 contract of Sept. 1960).

• Aviation Supply Office, 700 Robbins Ave., Philadelphia 11, Pa. "Indicators: Fuel Flow to support A4D-2N, 2 aircraft, N383-67462A dated—(383-216442-61)"—2279 ea —$27,205—Montrose Div., The Bendix Corp., South Montrose, Pa.

• Aviation Supply Office, 700 Robbins Ave., Philadelphia 11, Pa. "Fuel Control: To support Turbo-Jet engines on T2-J aircraft, N383-66660A, (383-253113-60)"—98 ea—$381,146—Woodward Governor Co., Rockford, Ill.

• HQS. San Antonio Air Material Area USAF, Kelly AFB, Texas. "2925-293-4810-(AA-10S) Igniter Plug; 2925-517-8295 (AA15S) Igniter Plug. Applicable to various engines in support of B52 Aircraft"—12900 and 11000 each—$108,718—Champion Spark Plug Co., Toledo, Ohio.

• Bureau of Naval Weapons, Washington 25, D. C. "Thirty-two J52-P-6 Engines and thirty-eight J52-P Metal Engine Containers in accordance with PWA Spec. No. N-1731. NOw 60-0218-1, Amendment No. 1"—$4,863,536—Pratt & Whitney Aircraft Div., E. Hartford, Conn.

• Bureau of Naval Weapons, Washington 25, D. C. Starters, Air Turbine, in accordance with Specification MIL-S-7848C (Aer) and MIL-S-19557A (Aer) Amendment No. 1 thereto. NOw 61-0102-F"—$257,324—Hamilton Standard Div., Windsor Locks, Conn.

• Bureau of Ships, Washington 25, D. C. "Gas Turbine Generator Set, Qty. 2 sys, (Inv. No. 622-1692Q) Contract Nobs-84074"—$832,420—Spec No. MIL-G-19995B (SHIPS) as modified—Solar Aircraft Co., San Diego, Calif.

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio. "Gas Turbine Compressors, GTC 85-56 iaw/Contractor's Model Spec SC-5259A dtd 17 Feb 57. Contractor's P/N 379374-1, FSN VH 2835-724-0088, (Navy Installations BV-1) and Data. Contract AF 33(600)41877"—33 ea—$422,712—The Garrett Corp., AiResearch Mfg. Co., Phoenix, Ariz.

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio, "Starters, Pneumatic, Aircraft Engine, Type MB-10, Aerno 42-9410, (Spares for B-52F, G and H Aircraft). Letter contract AF 33 (600)-42284 dtd 31 Oct 60"—219 ea—$81,468—Hamilton Standard Div., Windsor Locks, Conn.

• Bureau of Ships, Washington 25, D. C. "Hydraulic Pump Unit, Gas Turine Driven, 2 (Engineering Services), Contract NObs-84293, Executed 23 Nov. 1960, (IFB 600-101-61-S), Spec. No. SHIPS-H-3716 (As Modified)"—$99,997—Solar Aircraft Co., San Diego, Calif.

INDUSTRY NEWS . . .

AiResearch Contracts

New orders for air turbine starters and motors for the Republic F-105 have been received by The Garrett Corporation's AiResearch Manufacturing Division, Phoenix, Arizona. Total: $3.5 million.

In Full Production

The United States Navy has announced that it has awarded a letter contract in the amount of $34.2 million to Sikorsky Aircraft, a division of United Aircraft Corporation, for production of twin turbine HSS-2 helicopters. The HSS-2 will play a key role in the nation's anti-submarine warfare defenses when it goes into fleet service this year.

Titan Gas Turbines

US Army Ordnance District, Los Angeles, issued contracts to Solar Aircraft Company for Army procurement of one Titan engine-powered auxiliary power unit for possible support of the Lacrosse missile and a Titan turbine-powered winterization kit for the M-60 tank.

Pipeline Evaluation

Delivery of an 825-hp General Electric Model 722 industrial gas turbine has been made to Trunkline Gas Company for operating on a steady state duty cycle driving a DeLaval centrifugal compressor at a pipeline pumping station near Houston. Project is a part of a larger gas turbine testing and evaluation program being conducted by Trunkline.

The Model 722 engine operates on natural or manufactured gas. Its liquid-fueled counterpart, the Model 720, operates on a variety of fuels ranging from diesel oil to aviation gasoline.

Orpheus Turbojet

Another order for Bristol Siddeley Orpheus 805 (4000-lbt) turbojet engines has been placed with the company by the Defense Agency of Japan. Licence agreements, covering the manufacture of the Orpheus, have already been concluded with France, Italy, India and Germany.

Olympus Progress

The 20,000-lb thrust Bristol Siddeley Olympus 21 turbojet is to go into production under the Royal Air Force designation Olympus Mk 301. An advanced version of the Olympus has been specified for the British Aircraft Corporation TSR 2 supersonic strike/reconnaissance aircraft for the Royal Air Force, and versions with reheat develop thrusts up to 33,000-lb. The Olympus has immense future potential for use in aircraft flying at speeds up to about Mach 2.5. Current military development is such that it is a simple and relatively inexpensive step to a power unit in every way suitable for a supersonic civil transport.

15,000 lbt.

Pratt & Whitney Aircraft's LR-115, the nation's first liquid hydrogen rocket engine and powerplant for the Centaur space vehicle, has been fired continuously on test for the significant time of 5.5 minutes by P & WA, and over 30 minutes at intervals by NASA. (See page 35 of March-April 1960 issue for details.)

Thousands of hours of component testing have been covered using more than "10,000,000 gallons of the super-energy liquid-hydrogen fuel in this development testing—more than has been consumed by all other users in the nation."

200th Turbine Compressor

Boeing's Industrial Products Division has delivered its 200th gas turbine-driven compressor for airline ground support. The unit was a truck-mounted Boeing Turbo-Starter for delivery to Pan American World Airways.

VTOL Hawker

The successful completion of hovering trials by the Hawker 1127 vertical take-off strike aircraft is a historic achievement: "The Hawker 1127 is the first jet-sustained VTOL machine in the world to be designed for operational service, and its Bristol Siddeley BS 53 engine is the first jet engine in the world in which the whole of the thrust can be rotated to provide both lift for take-off and thrust for forward flight."

AiResearch Turbines Aboard Abroad

Orders for onboard small gas turbines as auxiliaries for two new European aircraft have been announced by The Garrett Corporation's AiResearch Manufacturing Division, Phoenix, Arizona. AiResearch turbines will be placed aboard both the German-French C-160 Transall, and the French 1150 Atlantique, the first use of onboard auxiliary turbines on foreign military aircraft.

Enters Scheduled Service

E. J. Specht & Dorothy Cornwell of GE and C. Belinn, Pres., Los Angeles Airways, inspect compressor

section of GE CT58 engine for the nation's first gas turbine powered helicopter in scheduled airline service.

Jet Maintenance Reduced

The Federal Aviation Agency has granted Delta Air Lines an extension in Time Between (conventional) Overhaul (TBO) for its General Electric CJ-805-3 turbojet engines from 800 to 1000 hours.

Tropical Testing

A Westland P.531 helicopter powered by a Blackburn Nimbus engine is now in Aden undergoing tropical trials. To date, trials are proceeding satisfactorily.

Correction

"All's Quiet in the City of Brotherly Love" (Gas Turbine, Jan-Feb.) was a correct title, but a premature judgment. Actually, the plant is not yet in service. Also, the silencer was included by GE as part of the installation, was not selected by Philadelphia Electric. The plant itself is located on an existing generating site on an island in the Schuylkill River at Norristown, about 20-miles from Philadelphia.

GT "COMING UP" REMINDER

MARCH 5-9 Gas Turbine Conference and Products Show, Shoreham Hotel, Washington, D. C.

MARCH 14-16 Society of Automotive Engineers, Inc., National Automobile Meeting, the Sheraton-Cadillac Hotel, Detroit, Michigan.

MARCH 20-22 Society of Automotive Engineers, Inc., National Production Meeting, Netherland Hilton Hotel, Cincinnati, Ohio.

MARCH 27-31 Instrument Society of America, 3rd Symposium on Temperature—Its Measurement and Control in Science and Industry. Sponsors: ISA, AMERICAN INSTITUTE OF PHYSICS, NATONAL BUREAU OF STANDARDS. Veteran's Memorial Hall and Deshler-Hilton Hotel, Columbus, Ohio.

APRIL 4-7 SAE National Aeronautic Meeting, including production forum and engineering display. Hotel Commodore, N.Y.C.

APRIL 10-12 American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., Open Hearth and Blast Furnace Conference, Sheraton Hotel, Philadelphia, Pa.

APRIL 17-19 Seventh National Instrument Society of America Symposium on Instrumental Methods of Analysis, Shamrock Hilton Hotel, Houston, Texas.

APRIL 17-21 American Welding Society Annual Meeting and Welding Exposition, Hotel Commodore, New York, N. Y.

APRIL 30-MAY 4 Seventh National Aero-Space Instrumentation Symposium Adolphus Hotel, Dallas, Texas.

MAY 7-10 American Institute of Chemical Engineers, Sheraton-Cleveland Hotel, Cleveland, Ohio.

MAY 8-10 Instrument Society of America, 4th National ISA Power Instrument Symposium, LaSalle Hotel, Chicago, Ill.

MAY 22-24 Instrument Society of America, 10th National Telemetering Conference, Sponsors: ISA, AIEE, ARS, IAS, IRE, Hotel Morrison, Chicago, Ill.

JUNE 4-8 American Nuclear Society, National Meeting, Penn Sheraton Hotel, Pittsburgh, Pa.

JUNE 4-9 Society of Automotive Engineers, Inc., Summer Meeting, Chase-Park Plaza, St. Louis, Missouri.

JUNE 6-8 Instrument Society of America, Summer Instrument-Automation Conference and Exhibit, Royal York Hotel and Queen Elizabeth Hall, Toronto, Ontario, Canada.

JUNE 28-30 Instrument Society of America, 2nd Joint Automatic Control Conference, Sponsors: ISA, AIChE, AIEE, IRE, University of Colorado, Boulder, Colorado.

GT PEOPLE PLANTS PLACES

W. H. Byrne

ASME Prexy

William Henry Byrne, recently-named 80th President of **ASME**, was born in New York City on August 11, 1900. He attended Stevens Institute of Technology and Polytechnic Institute of Brooklyn, graduating from the latter in 1923 with an ME degree.

In conjunction with his consulting practice he formed his present firm, **Byrne Associates, Inc.**, and in 1946 acquired **Sevens and Wood, Incorporated.** Both these entities provide design and drafting services, the former principally in the utility, industrial, and institutional fields and the latter in the marine-design and mapping fields. His engineering assignments have included many projects both here and abroad, entirely too numerous to list here.

Receives ASME Award

Carl Richard Soderberg, Institute Professor, **Massachusetts Institute of Technology**, has been awarded the 1960 ASME Medal "for his contributions to the development of steam and gas turbines for power generation and for propulsion units in naval vessels and in aircraft."

Harmon with Williams

Mr. R. A. Harmon is now with **Williams Research Corporation**, Walled Lake, Michigan. He is assistant to the president, **Mr. Sam Williams.** Bob Harmon has had an active career in the gas turbine business and remains as secretary of the Gas Turbine Power Division.

Inco New High Temperature Engineering Section

A new technical service has been established in the Development and Research Division of the International Nickel Company, Inc., according to an announcement by F. L. LaQue, Vice President and Manager of the division. This new High Temperature Engineering Section will serve industry on all problems arising in the use of materials in environments at elevated temperatures.

Dr. A. A. Kucher

SAE PRESIDENT

Dr. Andrew A. Kucher, newly-appointed SAE president, is also Vice President - Engineering and Research, **Ford Motor Company**, Dearborn, Michigan. A nationally-known engineer and inventor, Dr. Kucher joined Ford in April of 1951 as director of the Company's then newly-established Scientific Laboratory and was named to his present position in April of 1957.

Stratos Appointment

Appointment of a New York Metropolitan-Area Sales-Representative for its industrial turbo-machinery is announced by the **Stratos Division** of the **Fairchild Engine and Airplane Corporation.** The representative is **Malcolm W. Black & Co.** of 41 East 42nd Street, New York 17, N. Y.

Turbo-machinery produced by Stratos is widely used in the chemical processing industry both for power extraction and for the liquefaction of gases.

De Laval Names Manager

Captain Ivan Monk recently joined **De Laval Steam Turbine Company** as Manager, Service and Repair Department, pertaining to all products. Captain Monk has been active with the Bureau of Ships, first in charge of the Turbine and Gear department and later as Director, Machinery Division, Code 640, handling power plants. He remains chairman of the Marine Committee of the Gas Turbine Power Division.

Captain Monk's excellent record dates back to 1934, and includes Chief Engineer of several large ships between 1941 and 1946. One of these was the aircraft carrier Princeton.

Project Engineer Appointed

Theodore E. Borque has joined **Consolidated Diesel Electric Corporation** as Senior Project Engineer, responsible for design and development of new types of gas turbine-powered ground support equipment for aircraft and missiles.

A. H. Carameros

Made Committee Chairman

Mr. **Alexander H. Carameros**, Supervisory Engineer, **El Paso Natural Gas Co.**, has just been appointed Chairman, Operating Committee of the Gas Turbine Power Division of ASME. With headquarters in El Paso he heads up the Division Test Engineering group which includes operational design and maintenance engineering on gas turbine compressor units, pipeline, water treating, and non-destructive testing.

Wyman-Gordon Forms Special Turbine Applications Group

Wyman-Gordon Company of Worcester, Massachusetts, a leading producer of gas turbine components for missiles, rockets and aircraft, has organized a special group to concentrate on commercial—as well as military—uses of the gas turbine.

James L. Roach, vice president and director of marketing of the Worcester company, says:

"When the automotive industry is ready for forged gas turbine components, they will find that in research, development, technological know-how and production capabilities, Wyman-Gordon is ready, as the result of work long advanced in space and aircraft requirements."

Crucible Steel Appoints

M. J. Day, Vice President-Commercial, **Crucible Steel Company of America**, has announced appointment of **D. W. Kaufmann** as Product Manager of Stainless Steels. In this new capacity, Mr. Kaufmann will also be responsible for vacuum melted high temperature alloys, super alloys and titanium.

Al Bird Appointed to US Army Transportation Corps.

Albert F. Bird was appointed to the Office of the Chief of Transportation, **U. S. Army** this January. He received his B.S. degree from M.I.T. in 1930 in Naval Architecture and Marine Engineering.

In 1935, Al joined the U. S. Navy Bureau of Engineering, later BUSHIPS, and progressed upwards until he was transferred to the Defense Department in 1951 as coordinator of the Mechanical Equipment Panel, RDB. In 1958 Al Bird was appointed Chief of the Transportation and Ships Division in the new organization, Office of Director of Defense Research and Engineering.

In this post, he managed the division's work in coordinating the military departments' research and engineering on vehicles, engines, gas turbines and ships. As one particularly interesting task, Al originated and stimulated the cooperative efforts of the Army and Navy in preparation and issue of the current 600-hp gas turbine joint specification.

Al's future work in the Army Transportation Corps will deal with the technical aspects of vehicles, amphibians, over-the-beach cargo movements systems, and of course, gas turbines.

Boeing Appoints Euler

Appointment of **Donald J. Euler** as General Manager, Industrial Products Division was announced by William M. Allen, President of **Boeing.** Formerly Director of Planning at headquarters, Mr. Euler will become a vice-pres. Frank Korsberg, formerly General Manager of the division, will become Assistant General Manager, Marketing.

Euler was first hired by Boeing in 1928 as a part-time employee, while he was still attending the University of Washington. In 1931, upon receiving his degree in aeronautical engineering, he joined the company on a full-time basis, with the Engineering Weights Unit. In 1957, he was appointed Director of Operations, Planning.

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■ Many Delavan fuel injectors are developed specially for new or unique engines: experimental gas turbine automobile engines, for example. Requirements often involve a high degree of reliability for long periods of time, as in locomotive and marine fuel injectors developed by Delavan.

■ When you are considering a new or difficult fuel injection application be sure to consult with us. A Delavan designed and manufactured injector may well reduce costs, save you valuable time or improve the performance of your equipment.

■ Delavan can bring a fund of developmental experience and specialized manufacturing ability to your fuel injection problems . . . ability that is unparalleled in the industry. Delavan is the world's largest manufacturer devoted to the design and manufacture of fuel injectors and spray nozzles.

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DELAVAN Manufacturing Company

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For more information write in No. 10

English Electric's EM85

EE's new gas turbine extends power range of EM series . . .
built for fixed or variable-speed industrial or marine use

English Electric's new EM85 is the largest in this series of gas turbines. It is the outcome of experience gained in design and manufacture of turbines ranging from 3000 to 28,000 hp. It was designed for long service life. Total weight is 71,680 lb.

EM85 may be employed for either continuous or peak-load operation. It is capable of operating efficiently over a wide range of output speeds and is suitable for driving fixed or variable-speed machinery in industrial and marine applications. Normal rating is 8000 hp at 4900 rpm with an ambient temperature of 80°F and a barometric pressure of 14.7 psia. Thermal efficiency is 21%.

Careful design of individual components backed up by exhaustive component and model testing has made the EM85 an exceptionally compact engine with an attractive fuel consumption. Rugged mechanical construction, incorporating a comprehensive and entirely automatic air-cooling system, allows rapid starting and load-changing without setting up thermal stresses of any significant magnitude.

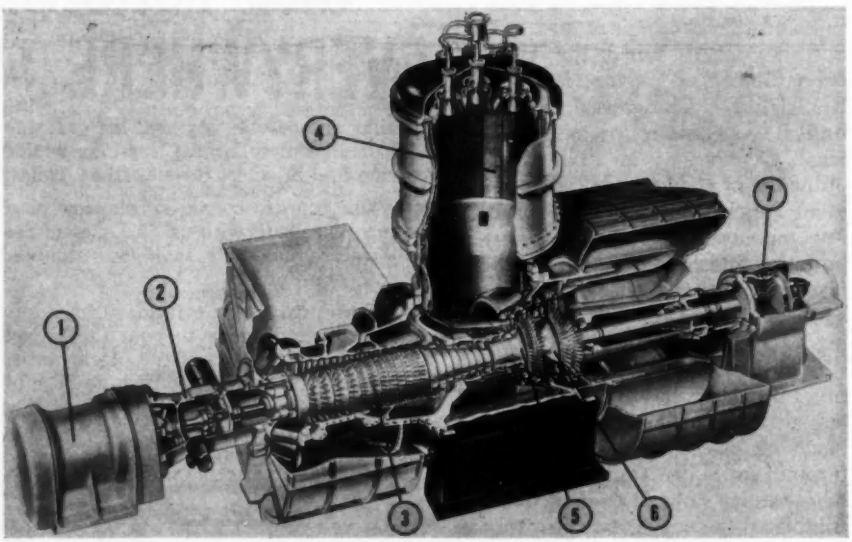
Extensive protective equipment and simple controls, fitted as standard on all English Electric gas turbines, reduce the required operating personnel to the minimum and greatly simplify start-up precedure. The combustion system is designed to accept a range of liquid and gaseous fuels.

Construction Details

The EM85 is a 2-shaft machine, with both compressor and power turbines overhung and mounted in series, adjacent to each other. Journal bearings are of the thin steel-backed type with white metal lining; thrust bearings are of the fixed-pad variety, comprising a white metal lining on a thin steel disc. High-temperature steel liners backed by internal lagging give protection to the main casings and the intermediate and power turbine bearings. Each of these is additionally cooled by air bled from the compressor.

Twelve stages of axial-flow blading of high tensile ferritic alloy steel are used in the compressor. The rotor itself is made from a single Ni-Cr-Mo alloy steel forging while the compressor casing is iron casting.

Air from the compressor passes between the mild-steel outer casing of the all-metal combustor and the high temperature inner components, thus cooling the outer shell. Primary air continues to the top of the combustion chamber and enters the flame zone by means of swirlers surrounding each burner. Secondary air is metered and passed through the walls of the



Two-shaft EM85 with 12-stage axial-flow compressor blading. Rotor is single alloy-steel forging. Compressor casing is a casting.

Whittle's Concepts . . .

September 3, 1946, Sir Frank Whittle, then Air Commodore, explained on the tablecloth the construction of his gas turbine jet unit to W. S. Morris (left), president of Alco Products, Inc., and your consulting editor. (Taken from the book Gas Turbine Construction by your consulting editor, then Manager, Research Department, American Locomotive Co.

Sir Frank Whittle envisioned the aft-fan, too

"Dear Sir,

As a new reader of your excellent publication, there is a matter to which I should welcome the opportunity to draw attention.

"I was extremely interested to see the reference, on page 40, of the September/October issue, to the foresight displayed in the many patents of Sir Frank Whittle. In case the specific reference to his British Patent No. 471368 should give the impression that Sir Frank was the originator only of the 'by-pass' (or 'front-fan') type of engine, I should like to make it quite clear that he also proposed the 'aft-fan' type, which, as is mentioned, the first example was built by Metropolitan Vickers. So far 'ahead of his time' was Sir Frank, that the 'by-pass' patents expired in most countries before 'front fan' engines came into use: patents on the 'aft fan' type still have some time to run, the most important U. S. Patent being numbered 2455458.

Yours faithfully,

T. G. Hicks
Managing Director
Power Jets Ltd.,
London, England"

English Electric

(*Continued from opposite page*)

louvered-type flame tube thus keeping the assembly at a safe operating temperature. Remaining air passes through slots in the mixing zone below.

Two high-energy igniters provide ignition. These, with the burners themselves, are mounted in the top cap of the combustor.

Compressor and power turbines each have two stages of blading. Compressor turbine blades are manufactured from Nimonic alloy. The first row of power turbine blades are made from Nimonic alloy and the second row from high-tensile stainless material. These turbines rotate in opposite directions, thus considerably simplifying the design of the stator blades between the two sections and increasing the efficiency of the combination.

An auxiliary gearbox, located at the front end of the compressor, provides drives for the lubricating and control oil pumps, the tachometer, generator and barring motor. Provision is also made for hand-barring the compressor shaft.

Installation

Intake and exhaust ducting arrangements depend entirely upon customer's specific requirements and conditions at site. Air filtration however, is generally considered essential and automatic oil-washed, self-cleaning filters are usually recommended. Noise levels at intake and exhaust are relatively low and generally it is only necessary to use silencing equipment where the plant is in residential surroundings.

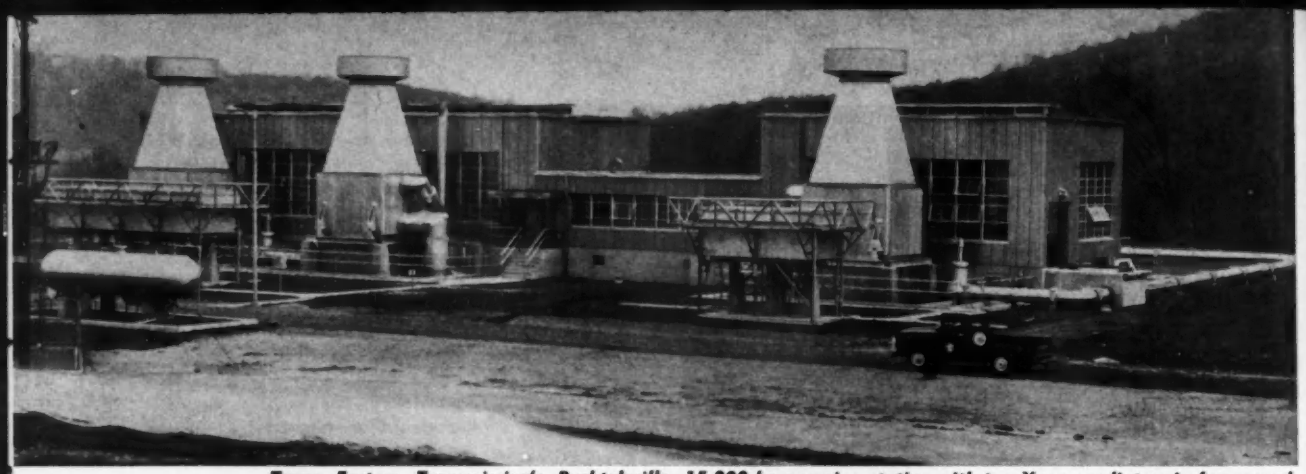
Performance Report On Another Model

We can add that English Electric type EM27 units are doing nicely, a report on two units being given below. Each unit is of the 2-shaft type with two combustors and normally rated 3000 hp.

The unit at Ashford Common operated by the Metropolitan Water Board, London, is on peak-load service, averaging 500 hours per year. It's rating is 2250 kw and it operates on diesel fuel oil.

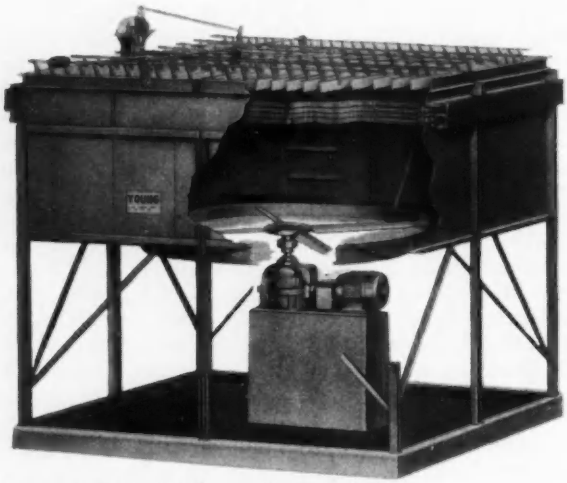
The unit at Edmonton in Alberta, Canada, is now operating on natural gas. Estimated cost of operating this plant is 2 to 3 mills less than the local cost of electricity which is between 10 and 11.5 mills per kw/hr. Rating is 1850 kw at inlet conditions of 59°F and 14.7 psig. A waste heat boiler is included in the cycle. It has an output of 10,000 lb/hr. of dry saturated steam at 10 psig under full-load conditions and with a feed water temperature of 60°F.

The unit is normally on peak-load operation running generally 8 hr per day during the winter and possibly as low as 3 hr per day during the summer.

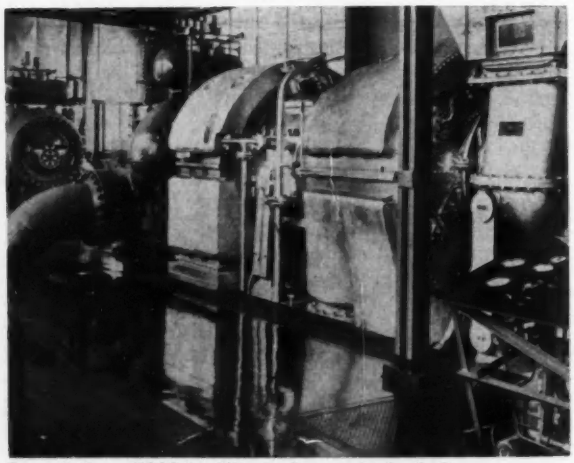


Texas Eastern Transmission's Bechtelsville 15,000-hp pumping station with two Young radiators in foreground.

Turbine lube oil cooled by Air



Cutaway view of a Young Horizontal Core Air Cooled Lubricating Oil Cooler. Shown in foreground of picture (above).



One of three 5000-hp Westinghouse single-shaft gas turbines at Texas Eastern Transmission Company's Bechtelsville pumping station. It drives a Cooper-Bessemer centrifugal compressor.

Functionally and economically oil-to-air coolers offer advantages in gas turbine applications.

Texas Eastern Transmission Company's Bechtelsville, Pa., gas pumping station is powered by three Westinghouse 5000-hp gas turbines. Since no cooling water is required by these prime movers, their lubricating oil is cooled in oil-to-air radiators. In fact, the whole lubrication picture is quite different from that in conventional gas engine-powered stations.

Little oil is consumed in a gas turbine. For example, annual cost of oil averages only about 2.5 cents per horsepower. This lube oil is used primarily for journal bearing lubrication and it is not exposed to contamination by combustion products. Thus it is not subject to oil changes at the customary frequency. However, the oil has a cooling function, picking up heat both from friction and the combustion process. Cooling is therefore necessary.

In this case heat is dissipated to the atmosphere by Young Radiator Company horizontal-core, oil-to-air radiator units. Heat dissipation amounts to about one Btu per min per hp.

These Young radiator units have done a good job of cooling lubricating oil at gas turbine compressor stations and, used as coolers and also condensers, in other gas and oil installations. For one thing, cross-winds or blanketed areas do not affect their cooling efficiency. Also, accurate control of cooling effect, regardless of ambient temperatures and cooling load, is maintained by modulating air flow. This is done by both fan and shutter control.

Oil-to-air radiators of this type fit in well with gas turbine installations in which water cooling is not required. They are effective, available in practically any capacity, require minimum piping and feature low maintenance costs. Elimination of water, its treatment and pumping systems are economic factors also favoring their selection.

The 90 years of experience, the skilled personnel and the excellent facilities that make Woodward governors the standard of the world for diesel and gas engine control have also established the standard in the gas turbine field.

WOODWARD®

Fuel Controls for Gas Turbine Engines

Woodward controls are in use on or have been developed for practically every type and size of gas turbine engine — power for boat propulsion . . . for aircraft propulsion and ground power units . . . for stand-by generator sets . . . for fire pumps . . . for air-borne power generator sets . . . etc.

In addition to speed governors in various sizes — isochronous or speed droop type — we build acceleration limiters, fuel control valves and differential relief valves to form an integrated fuel control system.

We will be glad to send more detailed information very promptly to builders of gas turbine engines and of equipment using these modern prime movers.

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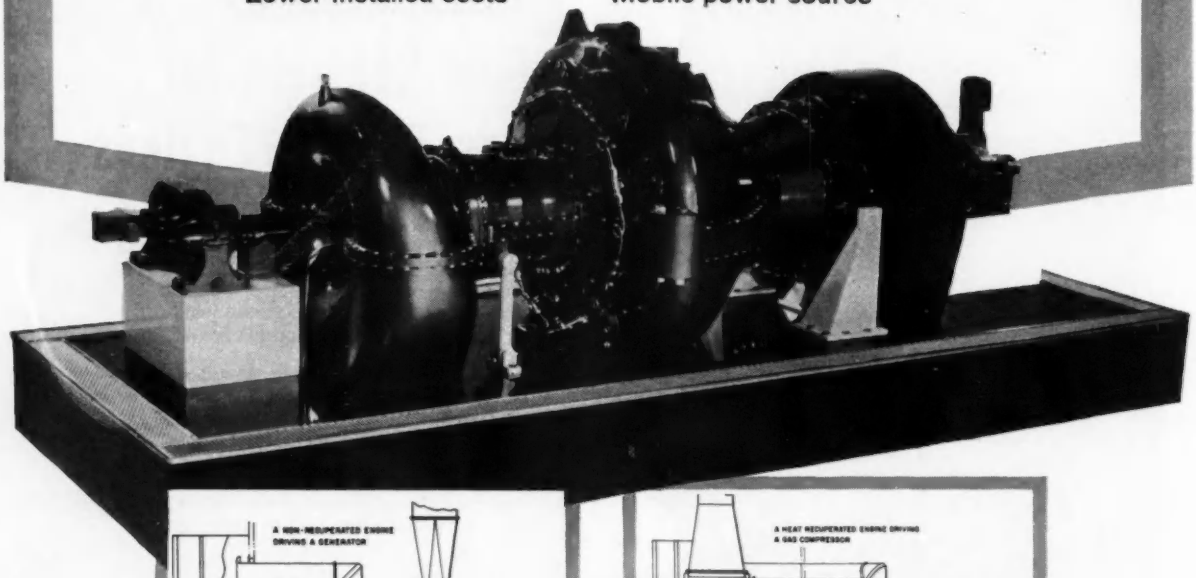
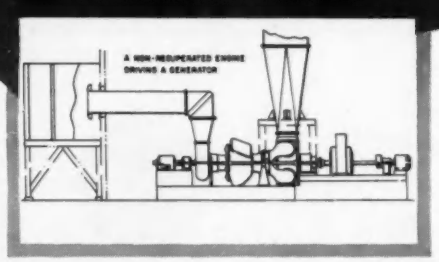
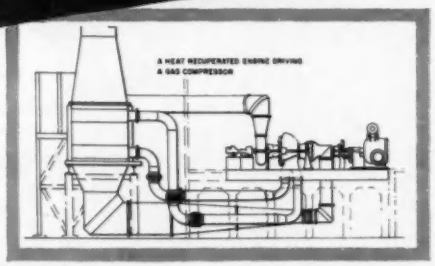
Gas and oil line pumping
Mobile power source







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Company Profile:

CAMERON TOOLS UP FOR THE FUTURE

Cameron Iron Works has a new 20,000-ton forging press in operation. It was designed by Cameron engineers and built at Cameron's Houston plant. Why would Cameron want such a press? What is its significance?

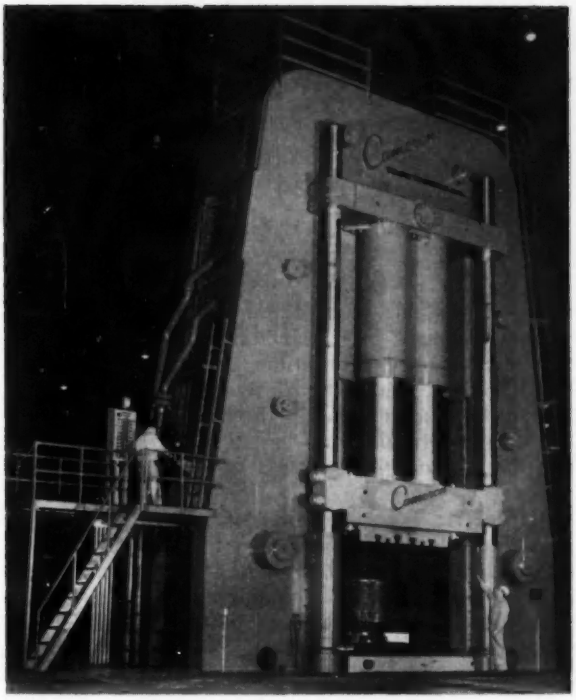
Here is part of the story as told by Vice President and General Manager Allen:

"We had been thinking for a long time about a press that would do some of the things that this one will do. We knew about what we wanted; we even had a wooden model of it. But it was not until one day last June that Jerry Brougher, head of our Special Products Division, came to me with word that a job was up, a very critical job, that we couldn't do. In fact, *nobody could do it with the equipment then available.* After we talked about it for a while I said, 'Jerry, it looks to me like the time has come to build the press we have been thinking about.' "

Then things began to move fast. It was a story of confidence and initiative, a story of dedication, back-breaking work and a crash program with a result that, according to Cameron officials and other competent authorities, is not only unique in what it enables men to do within the field of metallurgy and metal forming but is another classic example of what can be accomplished by all-out cooperative effort toward a desired goal under the free enterprise system.

As to significance of this new press, part of that story must remain classified as a matter of national security. But this much can be said. Bear in mind that high-density steels are forged into jet engine components; that stainless steels are forged into nuclear reactor and jet engine as well as steam turbine components; that high-quality alloy steels are forged into missile components; and that other materials such as pure molybdenum, refractory metals and tungsten are forged into many other sophisticated products.

Next, consider the importance of forging size. This press opens entirely new horizons as to the sizes, lengths and shapes of forgings that can be produced. And the forging process imparts physical qualities to the part that are not attainable in any other way.



Capacity of huge new press expands horizon of forging capability. First forging? 6000-lb gas turbine shaft! Potentiality? Bigger and better gas turbines!

Herbert Allen, Jerry Brougher, E. B. Blake and A. E. Caldwell.

Forging and shaping of metals by heating and hammering is as old as history. In forging, shape and grain pattern of the metal changes while the hot metal is worked. In press forging, metal is made to flow in a die and the metal forms a grain pattern in the direction of flow in the die set. This occurs as the metal is worked in plastic condition rather than being formed in a molten state as is the case in casting. Now, this can be true of piece sizes heretofore impossible.

First forging from this press was a gas turbine part, an aircraft shaft weighing 6000 lb. It was made of A286 stainless steel. Shaped like a funnel, it was 12.5-ft long with a large-end diameter of about three feet and had an 8-in. axial hole running through the shaft.

Development and building of presses of this type is not new to Cameron. In its plant it has presses of 750, 1500, 4000, 5000 and 11,000 ton capacity. The new press is believed the world's largest multiple-ram forging press. In the plant it is backed up with auxiliary equipment including a 4000-ton blocking and forming press and a 6000-ton shaping and punching press.

Its huge capacity both as to tonnage and dimension makes possible extension of the benefits of closed-die forging. In addition to the ferrous metals, others such as molybdenum, tungsten, tantalum, moly tungsten, tantalum tungsten, columbium and more exotic alloys can be handled. And Cameron Iron Works designed and built the press to open up this new frontier.

AC Electric Drive

. . . a new and improved link between gas turbine power and vehicular ground traction

Lack of suitable transmission systems is tending to keep light-weight gas turbines from assuming a more prominent position as prime movers for land and amphibious vehicles. The conventional means for converting the output power of the high speed (20,000 to 40,000 rpm) turbine into usable wheel power (about 100 rpm for large vehicles) can be materially improved.

A-C Electric Transmission Promising

A "breakthrough" appears very likely in the form of an a-c electric system developed by Jack & Heintz, Inc. A schematic diagram of this transmission is shown in simplified form in Fig 1. The system consists of three basic elements; (a) a-c Generator; (b) Frequency Changer; (c) Induction Motors.

The a-c generator that connects directly to the turbine is capable of handling full output of the turbine Electric output of this generator is fed to frequency changers from which power is distributed to motorized wheels. The outstanding advantage of this system is that it combines the simplicity, freedom from maintenance, and long life of an a-c system with the almost ideal characteristics of the d-c system.

A brief description of the major elements will aid in understanding the functioning of this transmission.

Motorized Wheel

Wheel-powering is accomplished with squirrel-cage induction traction motors. This type a-c motor is the most widely used, being extremely hardy and reliable. Also, it is smaller than a d-c motor due to its high rpm capability. Because it has no brushes, slip rings, or commutator, it is possible to encapsulate windings so that the motor can operate even immersed in water.

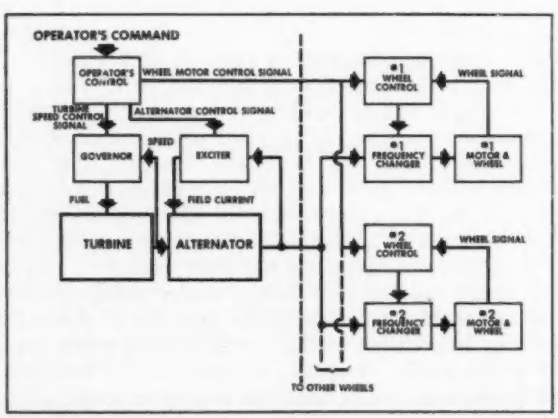


Figure #1—J&H electric transmission system (simplified) with a-c generator, frequency changer and induction motors.

Frequency Changer and Control

Present form of the frequency changer, which now makes practical an a-c transmission system for vehicles, was developed a number of years ago as a part of the Jack & Heintz Variable-Speed Constant-Frequency power system for aircraft. This VSCF development had as one of its aims, replacement of the normally-used hydro-mechanical device by a highly-reliable static device—an electronic black box. This black box eventually became the static frequency changer.

In essence, this component consists of a number of

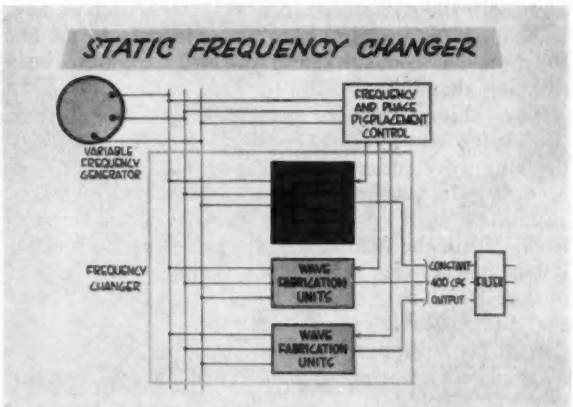


Figure #2—Frequency changer—the "black box"—consists essentially of a number of switches (shown schematically).

switches, shown schematically in Fig. 2, that are opened and closed at predetermined intervals. In this manner, a controlled frequency wave is fabricated out of small pieces of a number of generator frequency waves (See Fig. 3).

This process of opening and closing switches produces a jagged controlled-frequency wave which is smoothed by means of chokes (or filters). Circuitry is so arranged that frequency changer output is slaved to an oscillator. Hence, output frequency follows precisely the oscillator frequency, regardless of input frequency to the unit.

The switching device in this frequency changer is a silicon-controlled rectifier, Fig 4. This component can be rendered conducting or "switched-on" by means of a small pulse of current applied to the "gate." It ceases conducting or is "switched-off" when the anode-to-cathode current is forced to zero by other components in the circuit. This device is, therefore, the solid state equivalent to a thyratron.

The frequency changer of the type presented here has become a practical reality only since advent of this

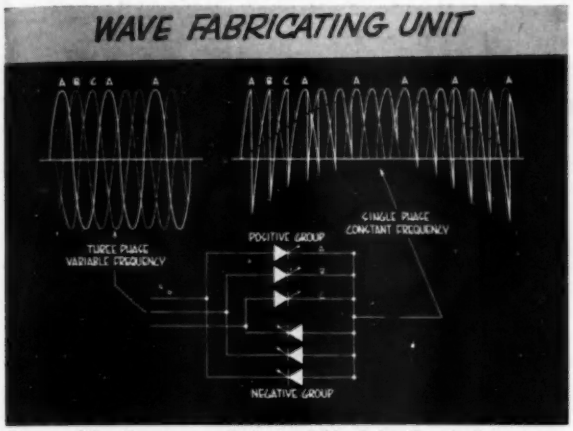


Figure #3—Opening and closing "black box" switches at predetermined intervals fabricates a controlled frequency wave from small pieces of a number of generator frequency waves.

new semi-conductor device, the silicon-controlled rectifier. Power-handling components of the frequency changer comprise a number of these silicon-controlled rectifiers (usually 18 or multiples thereof). In addition, there are a number (usually 9 or multiple thereof) of firing transformers used to fire the controlled rectifiers at appropriate times. These firing transformers are, in turn, controlled by a low-power signal (a few watts) from the driver's control station.

A-C Generator

The Jack & Heintz SECSYN (Stationary Exciter Coil SYNchronous) generator, Fig. 5, is a unique design of this type machine. This brushless machine has a conventional armature winding located in stator slots and a bobbin-wound d-c exciting winding attached to each of the end-barrels. The rotor carries no windings and it is comprised entirely of steel and other metallic parts, Fig. 6. Generator bearings are the only wearing components.

This type construction leads to an extremely hardy and long-life machine. Further, because there are no rotating windings, there is no necessity for rotor cooling. Because no rotating seals are needed, the stationary portion of the generator is adapted to oil cooling.

Figure #4—Switching device is a silicone controlled rectifier, "switched on" by means of a current pulse to the gate.

System Advantages

Advantages of the a-c electric drive system are manifold. Among the most salient benefits are:

Lower Weight: Indications are that significant weight saving can be achieved, especially in the generator.

Control Flexibility: Almost any conceivable scheme for driver control can readily be incorporated into the a-c electric drive system outlined here.

Ideal Speed/Torque Relationship: To achieve best possible vehicle performance, any transmission must deliver essentially all horsepower available from the turbine to the wheels under all conditions of speed. Torque/speed characteristics, Fig. 7, apply to the Jack & Heintz electric drive. This system provides an infinitely-variable speed ratio between prime mover and wheels.

Lower Cost Per Mile: Some facets contributing to this benefit are:

1. As just indicated, turbine speed has no fixed relationship to vehicle speed. Hence, a servo-controlled loop, sensing generator output power, can be utilized in controlling turbine speed. This permits operating the turbine on the *minimum fuel consumption profile* for all conditions of vehicle operation. Operating the turbine at preferential speeds at all times is expected to show significant improvement in vehicle specific fuel consumption.

2. Because components of the a-c electric drive are high-reliability, long-life items, per-mile operational costs will be lower.

Reverse Operation: Reversing is achieved without a gear change mechanism. It is attained by affecting a change in phase sequence to the motors that is accomplished by interchanging signal power loads (low power) rather than motor power loads.

Regenerative Braking: This feature is provided in the a-c electric drive system by reducing the frequency changer's output frequency to a value below the synchronous frequency of the motors (produced by wheel rotation). Under this mode, the motors will perform as generators, and the frequency changer, having the capability of bi-directional power flow, will supply power to the generator. The generator, in turn, now functions as a motor, returning energy extracted from

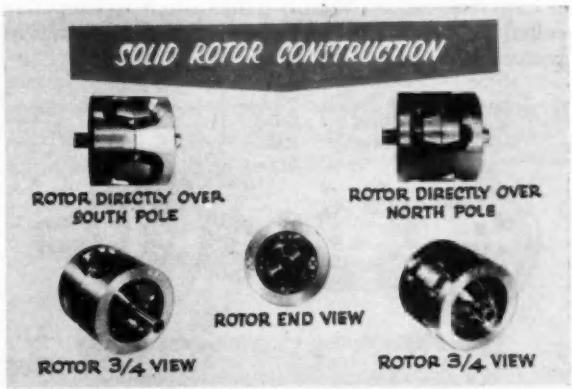


Figure #5—J&H's SECSYN generator has conventional armature winding located in stator slots, bobbin-wound d-c exciter.

Small Gas Turbines Today and Tomorrow

Abstracts from a speech by Dr. H. R. Scholp, Chief Engineer AiResearch Mfg. Div. of Garrett Corp., delivered before the Petroleum Engineers Club of Dallas on Dec. 9, 1960.

The Space Age started in 1957 with the first Sputnik. Today, more than 20 satellites are circling the globe. Of these, more than 18 are from the United States of America. Maybe we have concentrated too much effort to conquer space, and have left too many problems on earth unsolved. We don't even understand many things around us.

There is, however, one invention—the greatest ever made—which really benefited everybody. This is the invention of the wheel. Most of the progress which has been made is based on wheels. That is the reason why introduction of the gas turbine, that predominantly uses the rotary motion, has had and will have an increasing impact in the field of power generation.

As an example, a 350-hp gas turbine is 20-in. diameter, 45-in. long, weighs 250 lb. and has a fuel consumption of 0.65 lb per hp hr. Overhaul time will be 2000-hrs.

If weight and size are not such important factors, a heat exchanger can be added to recover exhaust heat. Weight will go up from 250 lb to 450 lb, but fuel consumption will be decreased to 0.45 lb per hp hr. Design life will be 5000 hours between overhauls. We predict that a gas turbine with good fuel consumption in the 600 hp range can be produced for $20 per horsepower on the basis of 1000 engines per year.

This new prime mover should not be considered just as a replacement for a reciprocating engine. It has its own characteristics and can do more. The more we become familiar with the gas turbine, the more we recognize that many more advantages can be obtained.

For example we at AiResearch have small a-c generators, not yet on the market, running at speeds as high as 48,000 rpm. Since this can be achieved, obviously much greater reliability can be obtained from this type of equipment because you have fewer parts, no gearing, and less complexity.

As I look at the next decades to the end of this century, there is no doubt in my mind that the gas turbine will be predominant as a prime mover in preference to any in the whole economy of the world.

A-C Electric

(*Continued from preceding page*)

the wheels, to the single-shaft turbine compressor unit where it is dissipated.

Regenerative Steering: By using the multiple-unit frequency changer approach, speed of each motor can be separately controlled. Thus, for vehicle turning, the frequency changer setting for the inside-radius wheels (or tracks) can be set at a lower value than that for the outside-radius wheels, thereby achieving regenerative steering. For tracked vehicles, this can be extended to include the pivoting condition.

Powered-Trailer Control: This system is admirably suited for the powering of trailer units. Total caravan power and control is housed in the lead unit.

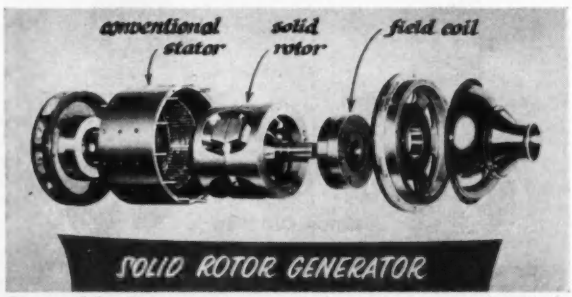


Figure #6—Rotor carries no windings, is composed entirely of metallic parts. Bearings are only wearing components.

Applications

For the present, it is believed that major a-c power transmission applications will be in those commercial and military vehicles which have off-highway as well as on-highway missions to perform and where flexibility, maneuverability, and reliability are factors of significant consideration. Multi-purpose trucks, personnel carriers, tanks, amphibious vehicles, self-propelled weapons and earth-moving equipment are among the most likely initial applications.

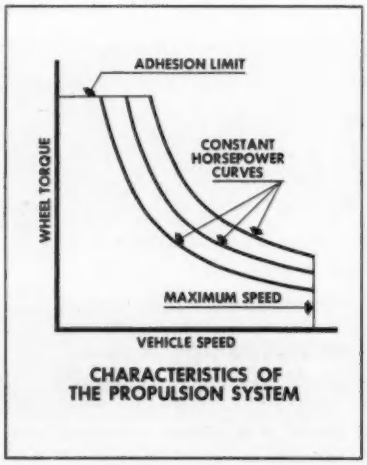


Figure #7—propulsion system provides infinitely-variable speed ratio between prime mover (power) and driving wheels.

Corp. Pervana Del Santa (Peru)
Empresas Electricas Asociad (Peru)
Beznaw Power Plant (Switzerland)
C. A. Venezolana de Cementos (Venezuela)
Tennessee Gas Transmission Co.
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Trunkline Gas Co.
United Gas Pipe Li
Texas Eastern Transmission Co.
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Public Service Company of Oklahoma
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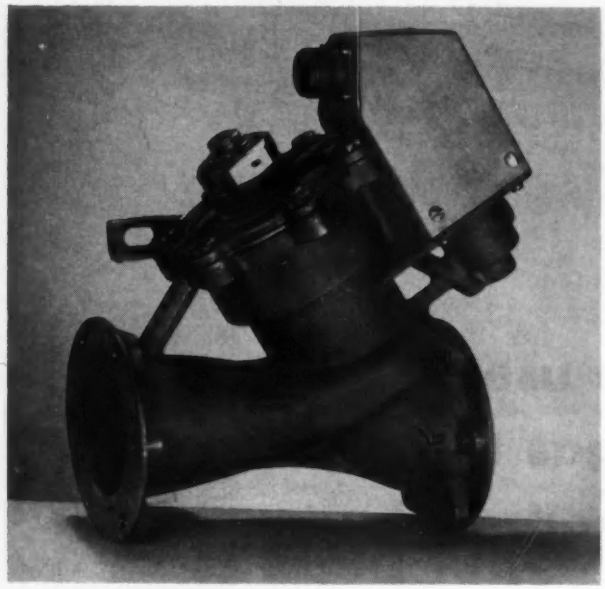


35-265 regulator and valve

Valves Control Hot Air Bleed

by Harry C. Foster
Engineering Manager
Pneumatic Equipment Group
Hydro-Aire

. . . can handle compressor bleed in tough functional and environmental conditions in aircraft.

Valves for controlling flow of high-temperature gases in aircraft service meet especially tough conditions. Also, there are stringent size and weight limitations imposed. This means that entirely new designs must be built for jobs such as the high-temperature compressor bleed air used for anti-icing, auxiliary air turbine power, ejector service, and similar services.

Aside from dynamic function of the valves, the most critical area encompasses proper selection of materials with respect to corrosion properties including electrolytic and intergranual, change in static and sliding clearances due to temperature changes, performance life characteristics under wear, and corrosive conditions.

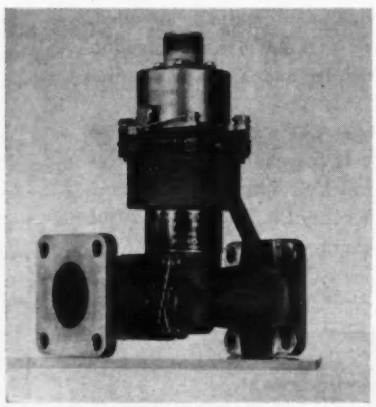
As to functional and external conditions, resistance of components to both internal and external contamination, without deterioration of materials or performance parameters, is essential. These contaminants include salt water, sand and dust, oil, and moisture.

Also, philosophy at Hydro-Aire for this type equipment does not allow use of filters to insure satisfactory component function. Then, of course, considerations include external effects due to alternate heating and cooling, radiation if applicable, and forces as produced by shock and vibration.

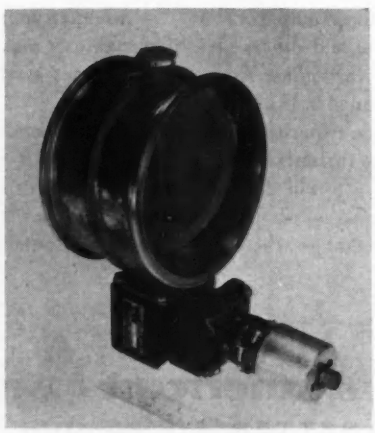
A review of a few of the typical high-temperature valves for control of anti-icing air to engine front frames and inlet guide vanes is as follows:

The 35-265 is used on the General Electric J-79 and CJ805 engines, and also used on the NATO F-104, the B-58, and the Convair 880 and 900. This is a 2-in. line-size pressure regulating valve, which has solenoid control and air shutoff. This valve supplies anti-icing air upon demand to the engine front frame and inlet guide vanes. This unit controls air from -65°F to 1000°F, in ambients from -65°F to 500°F, with a maximum operating pressure of 275 psig.

In the area of solenoid control gate valves is the 35-263 pictured.



35-263 gate valve



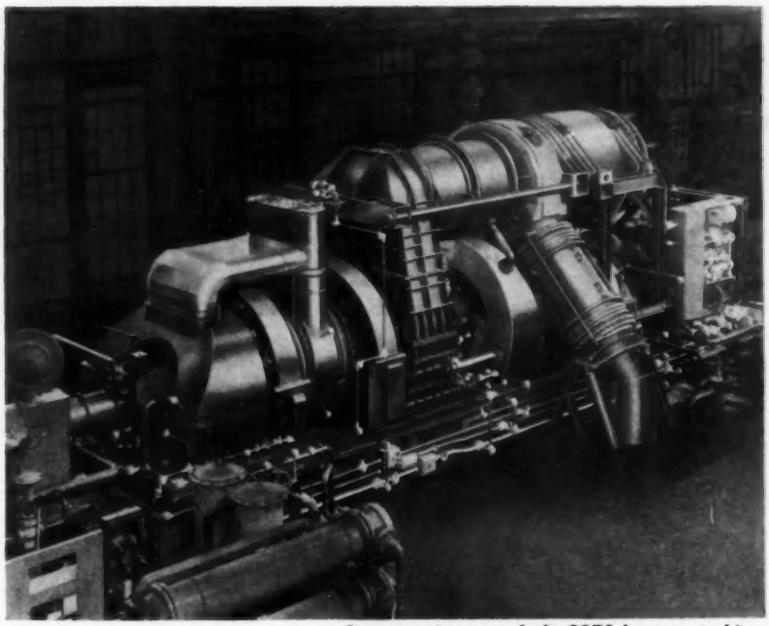
35-277A butterfly valve

This is d-c solenoid-operated with an operating pressure range of 10 to 206 psig, with a maximum fluid temperature of 230°F, ambients from -65°F to 250°F, with versions operating at ambients as high as 450°F. This valve is used in the B-52 air ejector system which provides ground cooling for an engine oil cooler, generator-driven oil cooler, and generator cooling. Different configurations of this valve, with respect to mounting, line size, etc., exist in the product line. Looking at butterfly-type valves, current size ranges run from ¾-in. to 6-in. These valves can be motor-operated, pneumatically-operated, solenoid-controlled, or pneumatically-operated from an external source. The 6-in. 35-277A is shown, motor-operated. It is built to operate in 200°F. Almost any desired opening rate can be obtained with this type of valve, resulting in approximately a straight line relationship between the time of opening and butterfly position. The opening rate is not affected by variations in voltage, temperature, or pressure. Opening rate can be set at 1 second or 60 seconds, depending on the application.

Control of high-temperature air flow to various surfaces for anti-icing or de-icing, as the case may be, can be done with some of these valves. The ice removal can be a serious problem with respect to jet engine operation. Equipment must either be actuated manually; by energizing an electrical circuit; or, automatically by a device which senses icing conditions. In many cases, even with manual operating, a device is needed to indicate icing conditions to the operator so that the system may be energized prior to excessive ice formation.

Hydro-Aire has under development an ice detection device which detects ice through the change of one parameter only and overcomes the operational difficulties of contamination of orifices, slow response time due to thermal lag, and lack of ruggedness. This device is now well beyond the feasibility phases and details will be released in the near future.

Such accessory items add to the number of possible functions of aircraft gas turbines. These are important: they add to the reliability and safety of the aircraft.



Regenerative two-shaft 8370-hp gas turbine.

Trans-Canada gets Three Gas Turbine Compressors

Clark Bros. 305's increase capacity of world's longest natural-gas pipeline.

Three gas turbine-centrifugal compressor sets have been delivered to Trans-Canada Pipe Lines Ltd. to power three new compressor stations. This is part of Trans-Canada's million-dollar expansion program to export natural gas to the United States. The turbine-compressors were sold by Clark Compressor Co., Ltd., Calgary, Alberta, a Dresser Subsidiary in Canada.

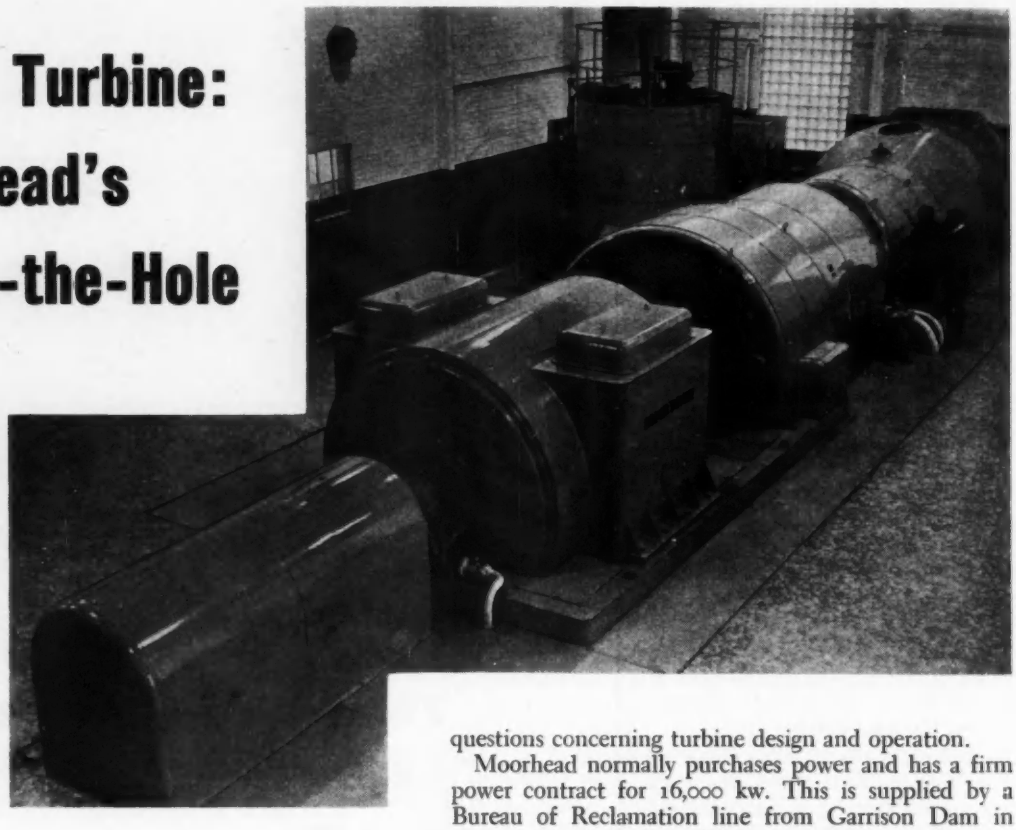
Turbines are Clark Model 305 regenerative-cycle, 2-shaft machines rated 8370 hp each (at NEMA conditions). They will drive Clark 30-in. x 30-in. single-stage centrifugal pipeline compressors which will pump approximately 700-million cu ft of gas per day through world's longest natural gas pipeline.

Centrifugal compressors are designed for future growth of the pipeline. The compressor volute is furnished as an insert within the outer case so that the same machine can handle high head—low flow at initial conditions, and later can be adapted for low head—high flow conditions with the insertion of new internal components.

These compressor sets will be located in three new compressor stations (Nos. 5, 9 and 17) which are being added to the western portion of the Trans-Canada line running through the southern part of Saskatchewan. The stations, located near Cabri, Herbert and Regina, are spaced between existing compressor stations powered by Clark 3400-hp reciprocating gas engine-driven compressors.

The turbine-driven centrifugal compressors have been equipped with specially-designed control systems that can be easily adapted to fully-automatic, completely-unattended station operation.

A Gas Turbine: Moorhead's Ace-in-the-Hole



Installed for fast emergency standby service additional uses are already considered.

On November 17th, 1960, the City of Moorhead, Minn., officially commissioned a Brown Boveri gas turbine in their Municipal Power Plant. This was a matter of extreme interest not only to Moorhead officials and the press but to many public utility officials from neighboring states and Canada.

Mayor Stenerson started the machine at the commissioning ceremony. Start-up was without fault and the machine was on the line at half-load in eight minutes. The following day a special technical demonstration was conducted for about 40 utility officials. Joseph Young, Superintendent of the Public Service Department, other engineers from Moorhead Public Service Commission and Brown Boveri were present to answer questions concerning turbine design and operation.

Moorhead normally purchases power and has a firm power contract for 16,000 kw. This is supplied by a Bureau of Reclamation line from Garrison Dam in central North Dakota. Vulnerability of this line requires that Moorhead have substantial emergency reserve capacity. Fact is that even before the commissioning, the machine was used twice in emergency operation.

Installation of the gas turbine will make it possible for the utility to shut down its steam units and still have fast emergency standby service available. By eliminating need for a spinning reserve using steam turbines, the gas turbine will quickly pay for itself in operational savings.

Peak load at Moorhead is rapidly approaching the 16,000-kw level. It is anticipated that the gas turbine will also prove valuable for peaking service. This means that further savings will be realized since availability of the gas turbine for this service will considerably delay need for installation of additional steam capacity for firm power.

Currently the machine is burning No. 2 fuel oil but in the near future use of natural gas is anticipated. This gas will come to the Moorhead area from Canada. Efficiency of the turbine on natural gas will be such that Mr. Young and the Public Service Commission are considering putting the unit into base load service and selling the power. Design of the Brown Boveri unit is such that it can operate successfully and economically in this type service.

So Moorhead has an ace-in-the-hole for use in emergency, for peaking and for base-load service.

From an original painting for CECO by R. T. Handville

KAMAN'S H-43B HUSKIE is powered by a Lycoming T-53 gas turbine with complete, single-package *fuel control and pumping system* engineered and precision-produced by Chandler Evans.

CECO's product in the Huskie is one of a number of "unitized" control systems developed expressly for the fast-growing small engine field. In addition to controls for application in manned aircraft, other lightweight, compact CECO engine control systems have been developed for target drones and missiles, while still others are available for auxiliary power units in airborne and ground support systems.

Chandler Evans *pioneered* single-package design of formerly separate fuel system components and today enjoys a position of leadership in the field of small engine fuel control and pumping systems.

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Interesting, informative literature on many CECO products is yours for the asking. Please address your request to Dept. G1.

CECO
SYSTEMS
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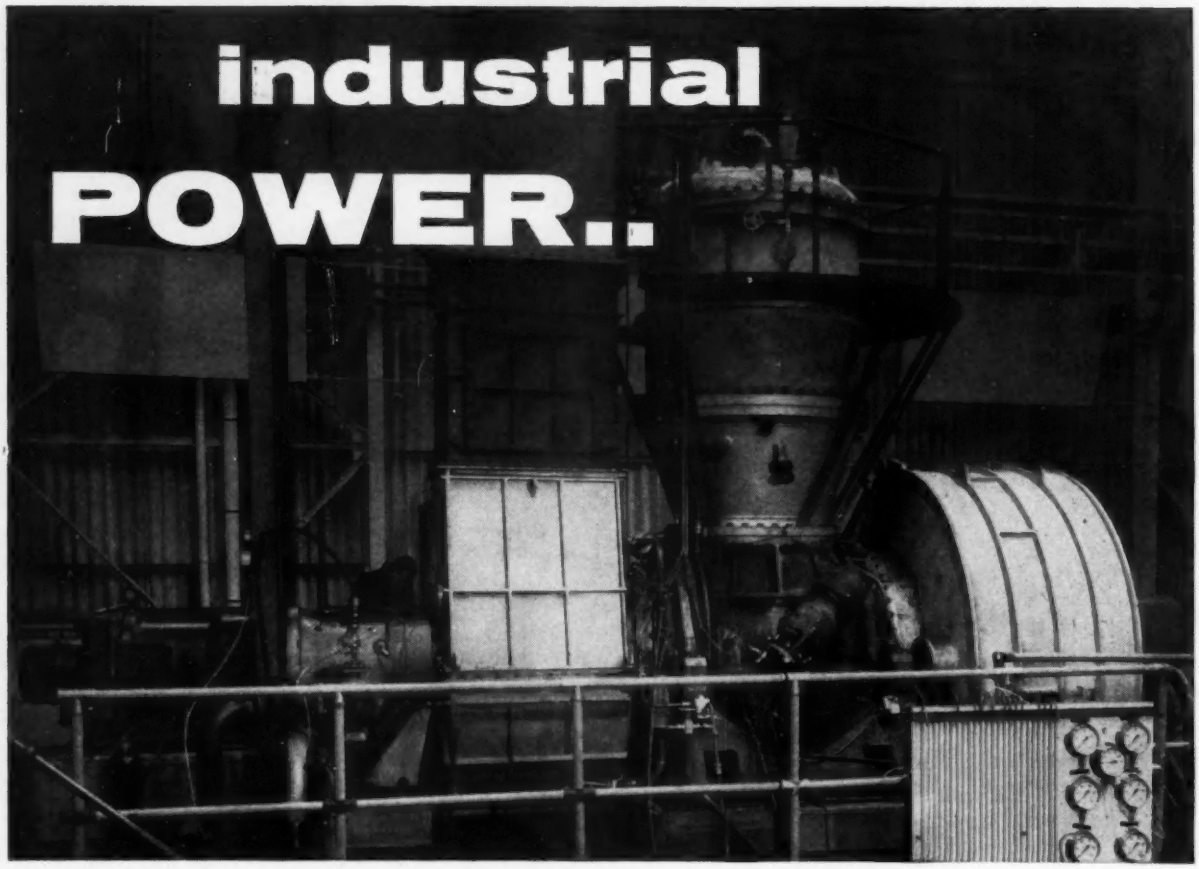
COMPACT industrial POWER..



An 'ENGLISH ELECTRIC' EM85 gas turbine undergoing works test. This is one of seven units being supplied to the Iraq and Basrah Petroleum Companies for pump drives.

'ENGLISH ELECTRIC'
industrial gas turbines

The 8,000/9,000 h.p. 'ENGLISH ELECTRIC' EM85 gas turbine—only 21 ft. long—is, for this power, one of the most compact two-shaft industrial units available. This multi-purpose turbine, operating efficiently over a wide range of output speeds, has an attractive fuel consumption and embodies experience gained with earlier designs ranging from 3,000 h.p. to 28,000 h.p. The exceptionally small size of the EM85 and the absence of reciprocating parts keep building and foundation costs low.

For technical details, send for Publication GT/104:

ENGLISH ELECTRIC EXPORT & TRADING CO. LTD., 750 THIRD AVENUE, NEW YORK 17, N.Y. Tel: MURRAY HILL 7-0303

GT.8

For more information write in No. 15

Seals for Gas Turbines

A survey of seal manufacturers . . . Who builds what for the gas turbine industry

Sealing problems in gas turbines are frequently aggravated by high shaft speeds, elevated temperatures and even difficult environmental conditions. Seal manufacturers, in meeting these new requirements, have had to turn to many new and ingenious devices. In many cases, seals are specially designed for specific applications; in others, standard seals can be used directly or with some modification.

To aid gas turbine designers who might be seeking sealing devices to solve their particular problems, this survey of some 17 seal manufacturers was made. Eleven of these indicated that their products were being or could be used on gas turbines. Breaking this down further, six manufacturers listed specific products for gas turbine use; one would build sealing rings on specific order; one supplied only carbon parts for incorporation in gas turbine seals; and three felt that their line of seals was so broad that they would suit many gas turbine sealing applications, certainly some of those on auxiliary components. Also, it was pointed out, many seals are supplied without the end-use being known.

Following are abstracts of information obtained from these eleven manufacturers:

Cartriseal Corporation

This manufacturer has a line of seals specific to gas turbine usage. They commented:

"Most of the applications involve high temperatures and shaft speed, sealing hot turbine gases from the bearings. Some applications use the bellows or "O"-ring, depending on location and operating conditions."

Chicago Rawhide Manufacturing Company

A set of prints detailing five seal designs for gas turbine use was received. Comment on these was:

"Seal selection is naturally a function of the operating conditions. The SK-2 and SK-3 are end-face seals, the SK-4 is a bellows seal and the SK-8 and SK-9 are controlled-clearance leakage seals."

The Cleveland Graphite Bronze Company

This company manufactures seals for gas turbines in both aircraft and industrial use. In SAE paper "Dynamic Seals for Aircraft Gas Turbine Engines," by Joseph Palsulich and R. G. Riedel of this company, illustrates the following types of seals. Labyrinth seals, lip-type seal (on a shaft), shaft seal (spring holding carbon seal to shaft), bore seal (spring holding seal against inner face of bore) and face seal.

Gits Brothers Manufacturing Company

"We manufacture and sell various types of seals for gas turbine applications," this company reported.

The catalogue includes the following face type shaft seals. "Met-L-Seal Temp. –65° to + 850°F. Chemical and Radiation Capabilities"; "Metal Bellows Seals Temp. –65° to + 400°F.

Koppers Company, Inc., Metal Products Division

This company manufactures both circumferential and face-type seals. Either type can be used on gas turbines, selection depending on application and the turbine builder's ideas. They qualify this as follows:

"However, the face seals commonly shown in our literature are for industrial use, and for use in gas turbines weights may be appreciably reduced."

Perfect Circle Corporation

This firm, a major builder of piston rings, had the following to say:

"We do make some metallic sealing rings for use in gas turbines for various manufacturers. The seals, generally, are basically similar to conventional piston rings with such modifications as may be required to adapt them to a particular turbine seal application."

Obviously, they have no standard line but have had experience in production of this type seal for specific gas turbine applications.

Sealed Power Corporation

Here is another piston ring manufacturer that can build sealing rings. They comment:

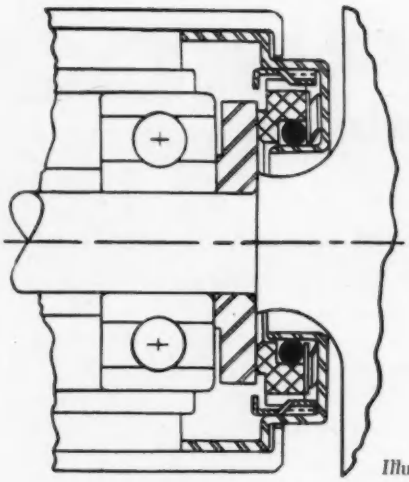
"We do not manufacture an open line of seals for gas turbines. Any such seals have been made according to specifications set up by the gas turbine manufacturers themselves and the only seals fabricated were for their own use."

Pure Carbon Company

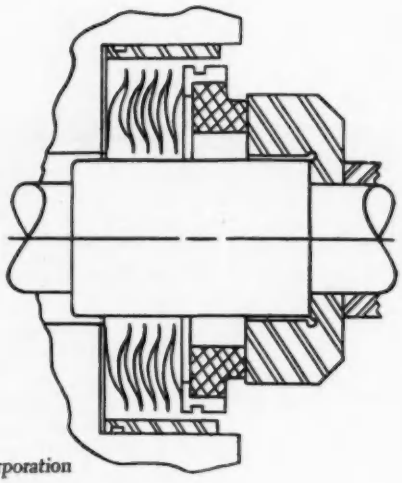
This organization produces carbon parts for seals; They told us:

"We do not manufacture complete seal assemblies

(Continued on next page)



High-speed turbine starter oil seal, typical "O" ring seal application.



High-pressure compressor seal, typical metal bellows seal application.

Illustrations courtesy of Cartriseal Corporation

but, in general, supply carbon seal noses either to seal manufacturers or directly to manufacturers who construct their own seal assemblies."

Garlock, Inc.

Garlock's broad line of products does not include a specific seal line for dynamic gas turbine shaft applications where high temperature and high speed are involved. They point out that:

"Packings are furnished to component manufacturers and, in the majority of instances, without information as to the specific application . . . There is no question but that in our broad line of packing that some of these products are finding use in sealing gas turbines and probably in both static and dynamic applications."

Rotary Seal Division,
Muskegan Piston Ring Company

Here is another company with a line of seals but with none specific to gas turbine usage. They state:

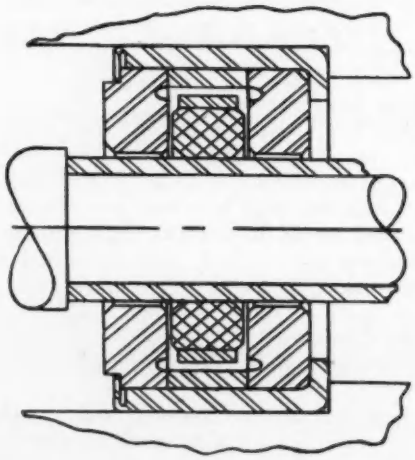
"All the seals that we manufacture are designed for use in the more common industrial applications, such as water pumps, hydraulic pumps, refrigeration compressors, gear boxes, etc. It is quite possible that some of these seals can be used in auxiliary equipment commonly incorporated in gas turbines."

Syntron Company

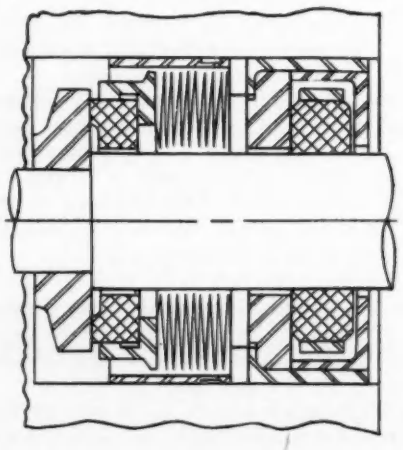
This seal manufacturer, when contacted, commented:

"We do not make seals for gas turbines as such. However, we do manufacture seals for rotating shafts and upon application we would manufacture seals for gas turbine use."

Within this group of seal manufacturers there is a tremendous amount of sealing know-how. The line of seals available, from production items to specially-built seals, is as broad as the range of sealing requirements of gas turbines and their accessory components. Those companies with either general or special lines have descriptive and technical literature available. Somewhere in this framework, turbine designers should be able to find sealing devices to meet their needs.



Air turbine wheel seal, typical floating labyrinth seal.



High-temperature gas turbine seal, typical metal bellows seal and floating labyrinth seal in combination.

Morse HY-VO® shatters roller-chain speed barrier!

PROVES IDEAL FOR GAS TURBINE APPLICATIONS

By far surpassing the speed limitations of roller chain, Morse Hy-Vo extends the advantages of low-cost chain drives to gas turbine applications. Running at speeds to 13,250 fpm., Hy-Vo offers the efficiency of high-speed, expensive gearing at lower cost. The designer can use the flexibility of chain in his power train without the disadvantages of gears.

Hy-Vo can handle gas turbines up to 1800 hp in main or auxiliary drives. Power is transmitted as smoothly and quietly as gears with superior load distribution. Compensating joint design fully eliminates chordal action normally encountered at very high chain speeds. Fill yourself in on the complete Hy-Vo story today and be ready for tomorrow. Write: Morse Chain Co., Dept. 44-31, Ithaca, N.Y. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

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WIDTH	7½" 4 strand	5"
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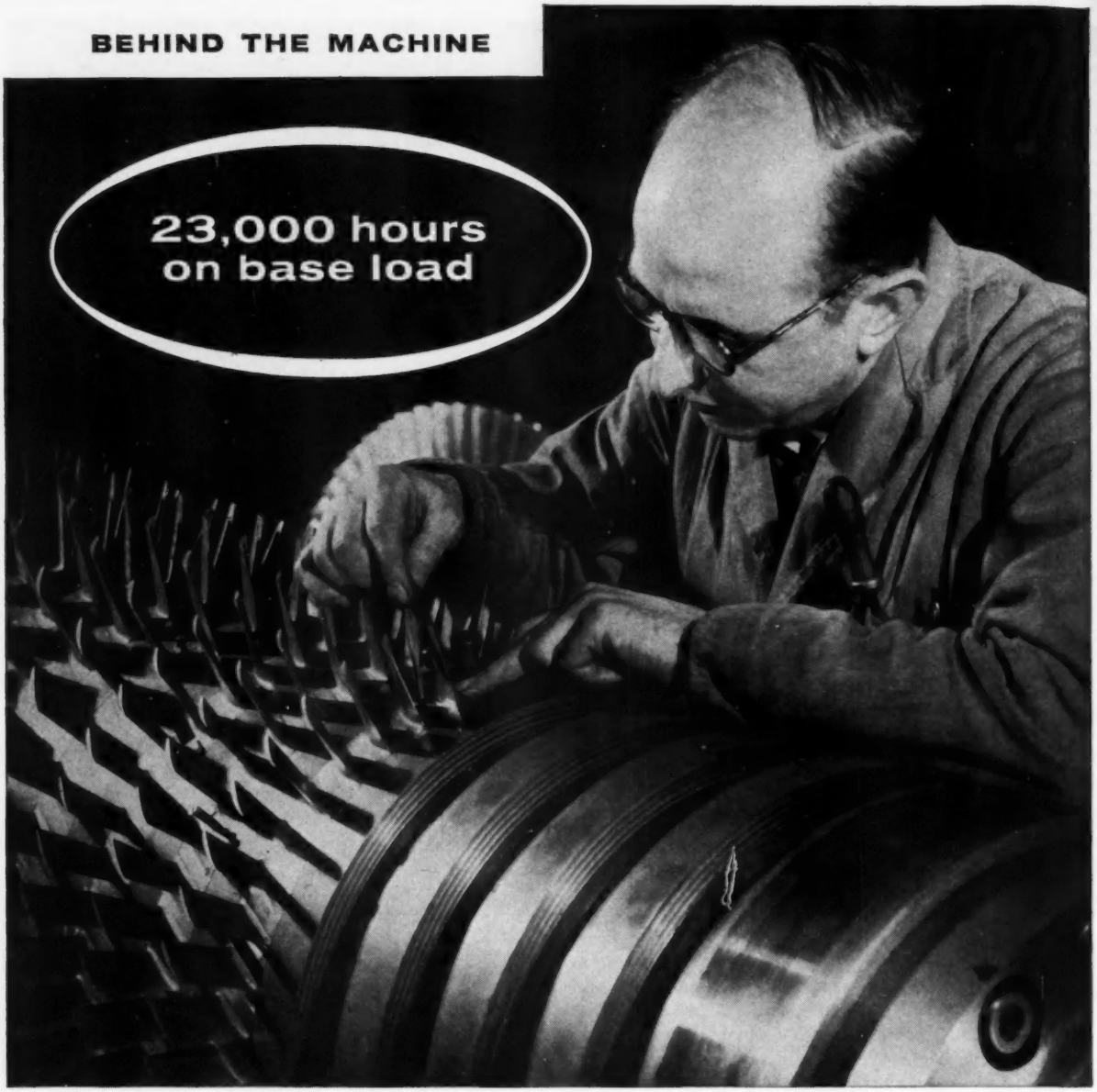
BEHIND THE MACHINE



The proved reliability of AEI industrial gas turbines is typified by a machine in Venezuela which has recently completed 23,000 hours running on base load. AEI makes a range of industrial gas turbines with ratings from 1,750 kW upwards designed to run on gaseous or liquid fuels.

The picture shows work on the compressor rotor of L2IC gas turbines being built, at the AEI Turbine-Generator Division Factory for the Basrah Petroleum Co. These feature a single shaft design which ensures stable regulation and makes them particularly suitable for parallel operation with other generating equipment.

This is a product of AEI Turbine-Generator Division, Britain's largest manufacturer of Turbine-Generators.

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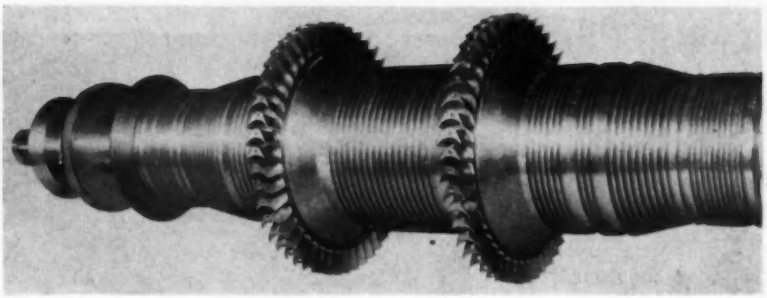
Expansion Turbines—What and Why?



Industrial expansion turbine and shaft machined by Schellens-True Corp. for the Worthington Corp.

An introduction to turbo machinery for use in the field of cryogenics.

Turbine expanders are used in the field of cryogenics where operating temperatures below minus 150°F are required. The important users of turbine expanders are in the following fields.

Gas Separation Plants (Oxygen, Nitrogen, etc.)
Chemical
Petrochemical
Refineries

Early cryogenic work that used expanders in the cycle was limited to use of reciprocating expanders. Turbo machines appeared with development of the low-pressure oxygen process and are now readily accepted. Today, the single-stage turbo expander is used for low pressure ratios and the multi-stage type for higher pressure ratios. Inlet pressures up to 600 psia are now handled with the impulse-type turbine.

Expander Types

Generally, there are four types of expanders: (1) Impulse, where all heat drop occurs in the nozzles and the rotating blades turn the flow only (Fig. 1); (2) Reaction, where part of the heat drop (often 50%) occurs in the rotating blades (Fig. 2); (3) Axial Flow (see Fig. 3); and (4) the Radial Flow, which can be radially inward (Fig. 4) or radially outward (Fig. 5).

At present, the most common types are the 50% reaction radial inward-flow expander, and the axial-flow impulse expander.

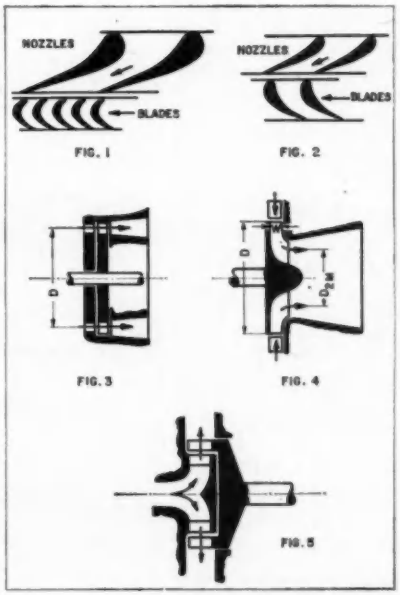
They are commonly referred to as the "radial expander" and "impulse expander" respectively. Radial expanders are mostly single-stage units while impulse expanders may be either single or multi-stage units.

If a low pressure ratio is required and end of the expansion ratio is not near the liquid region, the radial expander may be used. However, if accidental operation will allow the expander to handle liquids, the axial-flow type is preferred, that is, the axial-flow type with impulse blades given a moderate degree of reaction to reduce degree of liquification.

The axial-flow expander is better suited to handle entrained liquid or solid particles since all particles pass through the turbine only once and are not recycled. It is unlikely that particles are thrown back to the nozzles.

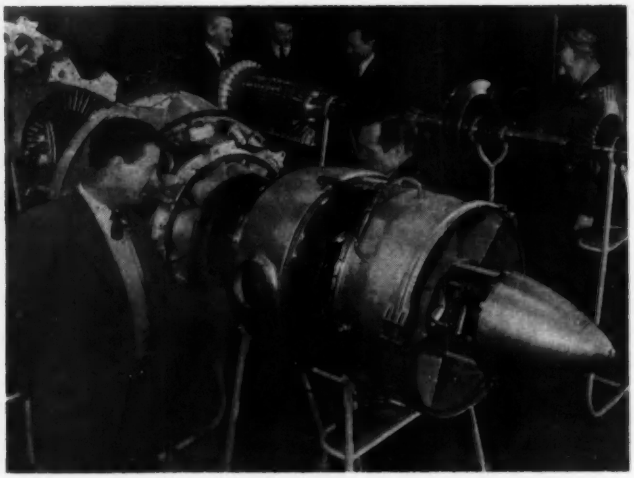
For very severe conditions the radial-outflow expander (Fig. 5) has been proposed. Centrifugal force would help to eject eroding particles.

Objective of this article is to provide an introduction to turbine expanders. Their uses are now multiplying, their sizes are rapidly increasing and they may now be purchased as a packaged unit. *For this information we are indebted to the Worthington Corporation.*

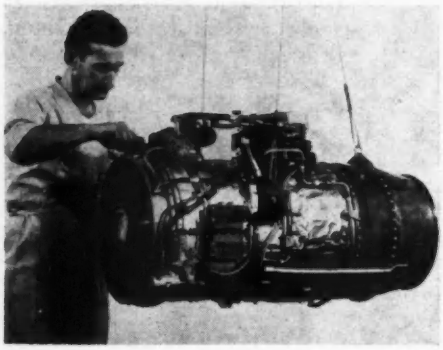


Four types of expanders and variation. Explanation is found in text.

GT PRODUCT NEWS



Bristol Siddeley's Aero-Engine
Working models, complete "exploded" engines and every type of component part for all Bristol Siddeley engines currently in service throughout the world are on display in the aero-engine school's two demonstration halls. Engines and components can be examined in detail. Pupils and instructors are shown examining an "exploded" Proteus engine and turbine and compressor rotors.



Raise Thrust/Weight Ratio
Ratio of GE's basic J85 engine (now 2700-lbt) has been increased to more than 10/1 for use as boost power plant for V/STOL aircraft. Weight is lowered and thrust is increased. Example: J85-7 (shown), 2450-lbt, is used on the McDonnell Aircraft GAM-72A "Green Quail" decoy missile.

Starter Unit, by Jupiter!
Navy ground crewmen prepare to start an F3H fighter with a new jet starter unit developed by Frank G. Hough Co. A 500-hp Solar Aircraft Co. Jupiter gas turbine engine, installed in the rear of the low-silhouette vehicle, supplies the compressed air to start aircraft engines.

B-70 Breathing Environments

An air inlet control system developed by Hamilton Standard for the Air Force's North American B-70 bomber has performed satisfactorily in wind tunnel tests. Control system underwent trials at the Lewis Laboratory of NACA to supply the plane's jet engines with the right amount of air at altitudes from sea level to 70,000 feet. Basic function of the control is to position shock waves—created at supersonic speeds—so that air can move freely to the engines. In addition, the system will measure the speed and pressure of air entering the inlet and automatically reduce or increase velocity and pressure as needed.

30

Oil Well Fracturing

The oil industry's first mobile gas turbine-powered oil well fracturing unit was successfully tested by Halliburton recently in the Sante Fe Field, Stephens County, Oklahoma, Kenneth Kiester Oil Company-owned well. Fracturing job took 22 minutes and resulted in a 50% increase in volume.

Powered by a 900-hp General Electric Model 720 engine, the fluid fracturing unit pumped 18,000-gal of water and 20,000 lb of sand into the hole. Maximum injection pressure was reported at 1750-lb and maximum injection rate at 27½ barrels a minute.

It looks like the gas turbine has found another field which it can definitely do a better job in than the piston engine.

31

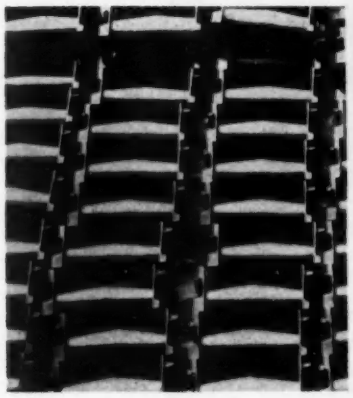
Nichrome V Tubing

Uniform Tubes, Inc., announces the production of tubing in sizes from .010-in. O.D. to .375-in. O.D. from this 80% nickel, 20% chromium alloy, with standard wall thicknesses down to .001-in. Known to withstand temperatures to 2100° F this tubing is made from Driver-Harris Co. Nichrome V.

32

Chromallized Turbine Vanes Resist High-Temperature Oxidation.

Looking like giant chains, rows of chromallized turbine vanes are being readied for shipment out of the Chromalloy Corp. plant in West Nyack, N. Y. These first-stage vanes will be installed in J-75 jet engines built by Pratt & Whitney Aircraft division of United Aircraft Corp., East Hartford, Conn. Chromallizing is a patented method of dif-



fusing chromium and other elements into steels, super-alloys, and refractory metals, to impart far greater resistance to oxidation at high operating temperatures.

33

AiResearch Test Stands

Orders for 23 mobile gas-turbine test stands and 90 engine analyzers have been received by The Garrett Corporation's AiResearch Manufacturing Division, Phoenix, Arizona. The new self-contained units provide a portable trouble-shooting test bed for any of the numerous current or projected gas turbine engines built by AiResearch for Navy auxiliary power use.

34

Improved Quick-Connect

Jack & Heintz, Inc., a prime designer and manufacturer of systems and components for the aero-space and general industries, announces production of a new design for No-Air Inclusion - type quick - connect couplings.

Tradenamed Trigger Lock and coded Series 17, these couplings form a complimentary line to the Series 10 and 11 Roto Lock couplings announced by J & H in June 1960.

Whereas the J & H Roto Lock couplings are directed toward general coupling applications, the new Trigger Lock is aimed specifically at those applications calling for minimum leakage on disconnect and minimum entrapment of air or other foreign matter on connect.

35

(Continued next page)

STALKER
ORTHOBRAZED
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Photo courtesy of Continental Aviation and Engineering Corp.

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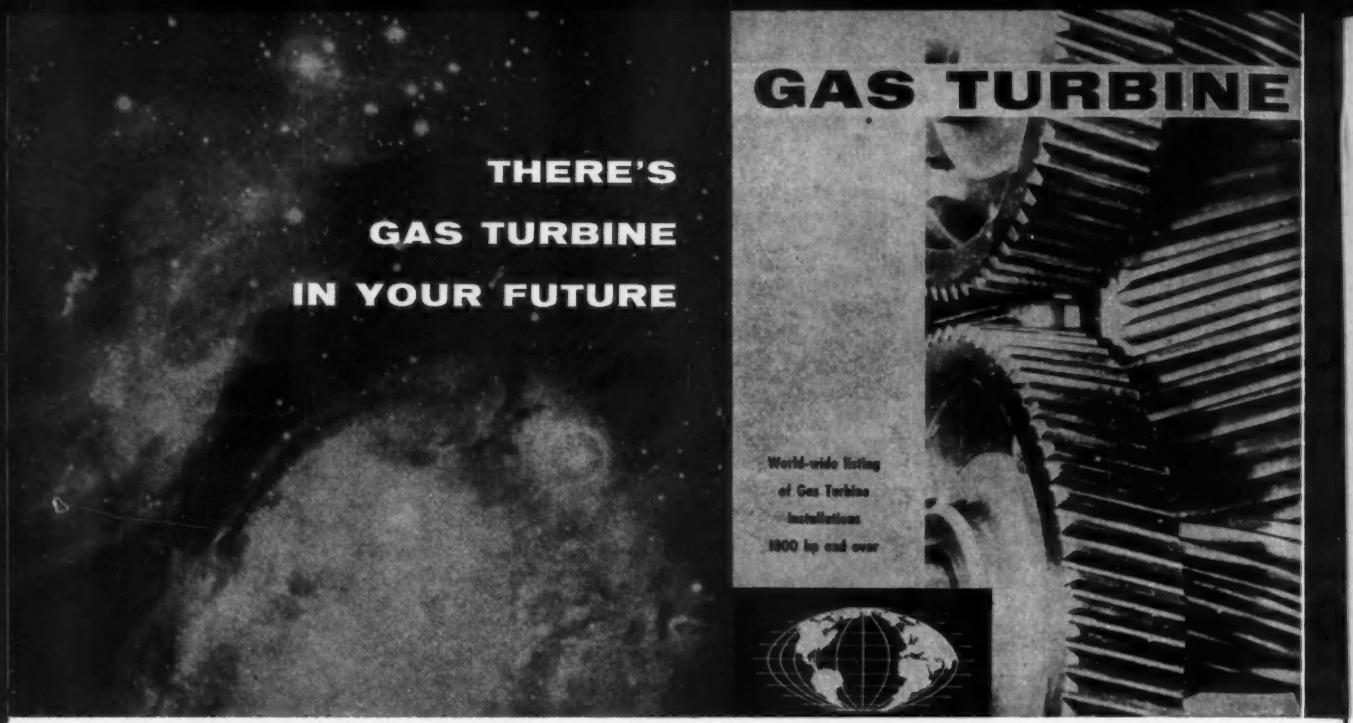

Publishers of Gas Turbine Magazine incorporating gas turbine power, Gas Turbine Catalog

hot line

industry news

contracts & procurements

coming events

people, plants, places

product news

patents

product-technical file

reader's service card

technical briefs

advertisers index

IN THIS FEAT OF TIME JUMPING, we shall substitute facts for the conventional crystal ball — facts which will give you a personal view of the purpose and scope of GAS TURBINE.

This is a bi-monthly publication devoted to the interests of design, application and operation engineers in the field of gas turbine manufacture as well as the many fields of commercial and military usage.

Technical articles are written by recognized authorities, edited by specialized engineers and a skilled team of journalists. GAS TURBINE describes in clear, concise and colorful terms, refinements in gas turbine components and accessories — new ideas that increase efficiency and open up new fields of application.

As a reader of GAS TURBINE magazine, you will know what others are doing with gas turbine power, and how you can profit by their experiences. You will know about all the latest uses in vehicles, aerospace, power generation, processing industries, marine applications and many more.

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PRODUCT NEWS

(Continued from page 39)

Approaching 50,000 psi

355 standard aluminum alloy is being investment cast and in the T7 condition gives an ultimate tensile of 49,500 psi with a 3% elongation per 1-in gage length. Typical tensile is 45,000 psi with a 4% elongation.

This advancement is only a part of the development program accomplished by Precision Metalsmiths to produce investment castings faster, with higher quality, and at lower costs.

36

Film Traces First Gas-Line Application for Stationary Jet

How "The Constant Search" led to the first industrial gas line power application of a stationary jet aircraft engine is told in a new free 16mm-sound film in full color, made available by The Columbia Gas System to technical schools, colleges and interested adult groups through Modern Talking Picture Service. Prints may be borrowed from Modern's film libraries in the area served by the gas system. This includes Kentucky, Maryland, New York, Ohio, Pennsylvania, Virginia, West Virginia and Washington, D. C.

37

Hi-Altitude Helicopter

In 1960 the India Air Force purchased a Sikorsky three-bladed S-62A which carried a one-ton payload to 14,000 feet, believed unprecedented for a helicopter of this weight class. An improved S-62B has now been purchased, the first four-bladed machine of this model sold by Sikorsky. Its General Electric CT58-100 gas turbine is derated to 730 horsepower, leaving a reserve for this service.

38

Tests More-Than-Satisfactory

First test-stand run of Continental Aviation Engineering's Model 217 500hp turboshaft engine took place ahead of schedule, and all initial test objectives were reported met.

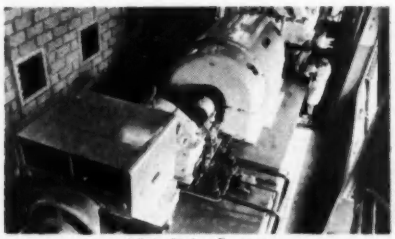
Model 141 gas turbine air compressor powers a radically new helicopter designed by Monte-Copter, Inc., Seattle, in which cold compressed air, ejected through blade tip nozzles, provides thrust for 3 dimensional maneuverability.

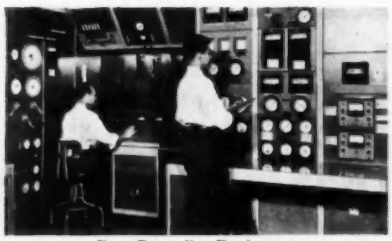
39

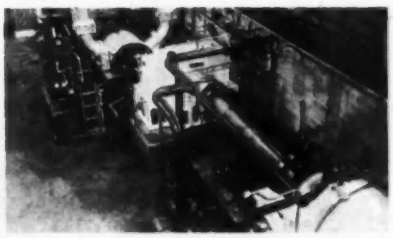
Lycoming Test Successful

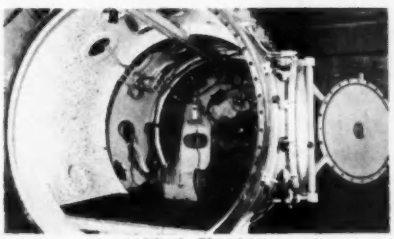
Completion and acceptance by the Air Force of the 150 hour military qualifications test for the Lycoming T55-L-5 gas turbine engine was announced by Avco Corporation's Lycoming Division, Stratford, Connecticut. Test results in all cases met or exceeded guarantees. Rated at 2200-shp for standard day it demonstrated 2360-shp. Weight was 558 pounds, a weight ratio of 3.94 to 1. Acceleration time from flight idle to full military power was 3.1 seconds, well below the guarantee of 3.8 seconds.

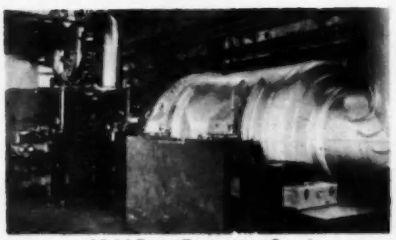
40

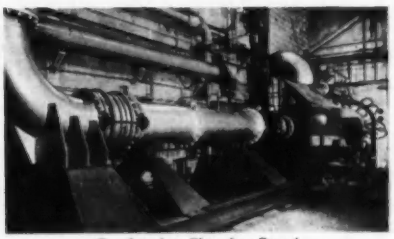

Main Drive System


Data Recording Equipment


Turbine Test Stand


Altitude Chamber


Multi-Stage Compressor Stand


Combustion Chamber Stand

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See Gas Dynamics Laboratory model at Booth 28 during Gas Turbine Conference

For more information write in No. 19

PRODUCT TECHNICAL FILE

Bolting Bulletin

A 24-page selection guide to SPS bolts for the aerospace industries is being offered by Standard Pressed Steel Co. Also included are tension and shear bolts, engine bolting, titanium and specialty fasteners—AN, MS, NAS and SPS standards. **41**

On Instruments

A new illustrated short-form catalog is now available, describing a broad range of instruments produced for The Korfund Company, Inc., by Philips of the Netherlands, for measuring, recording, and analyzing vibration and strain. **42**

New Publications

English Electric has just issued a new pamphlet, obtainable from their New York office, 750 Third Avenue. This pamphlet summarizes the activities of English Electric here and overseas. **43**

High Gear

This Western Gear Corp. publication frequently has gas turbine news. The Nov. 7, 1960 issue gives an interesting account of the 4-speed transmission built to operate between the Solar Saturn 1000-hp turbine and its Western Company fractioning pump, used in the oil well servicing industry. **44**

Visual Indicator

This is only one of the features described in a new bulletin by Dynamic Filters Inc., affiliated with Michigan Wire Cloth Co. The many filters made from "simple-to-complex," conventional barrier-type strainer to "sophisticated" filtration, are illustrated. **45**

Norton Company's New Mounting Bulletin

"Mounting Sensing Elements" describes methods of mounting temperature and strain-measuring elements by means of ROKIDE ceramic spray coatings. This technique is being used to mount such elements in areas subject to high temperatures, such as rocket nozzles, gas turbines, and nose cones, particularly in testing operations. **46**

Why Gas Turbines

Gas turbine operators are interested in "New Frontiers," The Garrett Corporation publication. In the Fall issue is a good article on "Small Gas Turbines . . ." and an unusually fine one by Dr. W. T. von der Nuell, "Why Gas Turbines Also in the Oil and Gas Industry?" **47**

Standardization

A new brochure explains DeLavan's dual orifice nozzle for the smaller gas turbines. The nozzle is high quality, suitable for wide application at moderate cost, due to the large utilization of many production components. **48**

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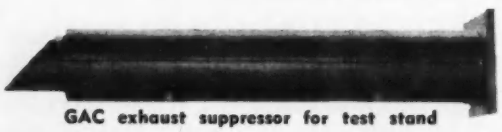

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Liquid Meters

Bulletin #800 outlines the "skilled hand" of the Liquidometer Corp., for the past 40 years. They've been makers of precision instruments. Four-page bulletin #463A describes many tank contents gauging systems, a very complete line for all uses. 49

Bendix Go-No-Go Gage

A new four-page technical brochure discussing the Go-No-Go fuel cleanliness gage for aircraft fuel transfer operations is now available from Bendix Filter Division, The Bendix Corporation, Madison Heights, Michigan. This brochure discusses the various functions. These include the checking of the full-flow of fuel; instantaneous reaction to contamination; and full cut-off of fuel flow when contaminated above a predetermined level with water and/or solids. The gage is used in conjunction with such equipment as filter-water separators, refueler carts, hydrant systems and fuel-filter testers. 50

Gas Turbine Chain Drive

Morse Chain Company, Ithaca, New York, has developed chain drives for transmitting power of gas turbine engines . . . 30 to 1800-hp. These chains are applicable to main or auxiliary drives and incorporate compensating links that fully eliminate chordal action normally encountered at very high chain speeds. "Hy-Vo" is a modern chain for modern power. Better look into it. 51

Bristol Siddeley Journal

The 1960 Autumn issue is well filled with gas turbine news, including "The Case for the High-Ratio Ducted Fan," "Bristol Siddeley at Farnborough, 1960" and "The Study of Vibration Modes in Compressor Blades." 52

Milepost: November 1960

This issue published by Columbia Gulf Transmission Co. tells the story, first on TV, and then in this issue of the Jet Operating on Possum Trot Ridge. Operators of gas turbines can avail themselves of the full account, to date, of the Cooper-Bessemer and Pratt & Whitney Aircraft pumping plant. 53

Engineering Manual Solves Line or Duct Problems

A free 12-page manual provides detailed information on pressure and bend ratings, fitting styles and installation practices for the line of all-metal flex hoses and lines made by Flexonics Corp. A wide assortment of end attachments is described for high-pressure fuel and lubricating lines, and hydraulic and pneumatic lines. Scale drawings to assist solving these problems are included. Send for catalog #200E. 54

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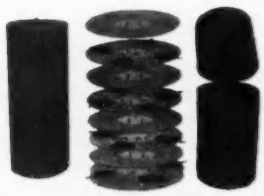

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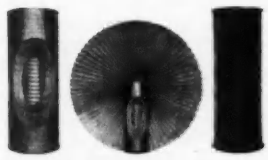

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GT TECHNICAL BRIEFS

Annual SAE Meeting, Detroit, Michigan, January 9-13, 1961. Monday the 9th was an all day session on Gas Turbine Compressors, a very worthwhile meeting. The papers presented were:

Aerodynamic Design and Performance of Centrifugal and Mixed Flow Compressors, 268A by F. Dallenbach, Staff Engr., AiResearch Mfg. Co. of Arizona.

Influence of Impeller and Diffuser Characteristics and Matching on Radial Compressor Performance, 268B by Colin Rodgers, Analytical Engr., Solar Aircraft Co.

Transonic Flow Problems in Centrifugal Compressors, 268C by A. F. Stahler, Assoc. Res. Engr., Industrial Prods. Div., Boeing Airplane Co.

The Combined Transonic Axial and Centrifugal Stage Compressor, 268D by C. J. Rahnke, Dept. Hd., Component Design and Dev., and R. H. Carmody, Proj. Engr., Compressor Design; Continental Aviation & Engrg. Corp.

The Development of the Chrysler Automotive Centrifugal Compressor, 268E by A. H. Bell, Managing Engr., Gas Turbine Components, G. A. Ball and L. B. Mann, Turbine Res. Specialists; Chrysler Corp.

The Role of the Compressor in Limiting Automotive Gas Turbine Acceleration, 268F by C. A. Amann, Supv., Thermodynamic Design and G. E. Nordenson, Res. Engr., Engrg. Dev. Dept., General Motors Research Labs.

Wednesday the 11th there were two excellent papers:

Army's View of Future Needs for Small Power Sources, 297A by Lt. Gen. A. G. Trudeau, Ch., Res. and Dev., Department of the Army. This paper gives an excellent progress report of the gas turbine in the Army.

The Development of the Ford Model 704 Gas Turbine Engine, 291A by I. M. Swatman, Design and Dev. Sect., Turbo Machines Dept., Ford Motor Co. This paper gave a fine detailed report well illustrated.

On Friday the 13th a closed cycle gas turbine was described in the following paper:

Gas-Cooled Reactors for Mobile Application, 308B by G. G. Leeth, Principal Engr., Advanced Nuclear Concepts, General Electric Co.

Papers Presented at ASME Annual Meeting, New York City, November 28-December 2, 1960.

Resume of Transonic Compressor Research at NASA Lewis Laboratory by Seymour Lieblein, Aeronautical Research Engr. Special Projects Panel, Fluid Systems Div., and Irving A. Johnsen, Asst. Chief, Fluid Systems Div., NASA, Lewis Research Center, Cleveland, Ohio (No. 60-WA-97).

This paper presented a summary of the major research effort on transonic axial-flow compressors conducted by the NACA Lewis Laboratory. It contains a historical review together with a listing of the projects covered. Major results and contributions of the program discussed and a bibliography of published papers are included.

Shock Losses in Transonic Compressor Blade Rows by Genevieve R. Miller, and George W. Lewis, Jr., Aeronautical Research Engineers and Melvin J. Hartmann, Supervisory Aeronautical Research Engineer, Head, Pump Section, Fluid Systems Div., NASA, Lewis Research Center, Cleveland, Ohio (No. 60-WA-77).

A simple method of predicting shock losses in transonic compressor blade rows has been developed. This method has been found to be reliable when tested by two direct experimental evaluations. Shock losses can, by the method given, be easily incorporated into compressor design systems.

A Review of Supersonic Compressor Development by John F. Klapproth, Supv., Compressor Development, General Electric Co., Cincinnati, Ohio. (No. 60-WA-294).

The history of the supersonic compressor development is reviewed and compared to present compressor design criteria. Limitations imposed by flow separation criteria are discussed, and performance assuming separation for those designs exceeding current limits is estimated.

Critical Highlights in the Development of Transonic Compressors by Robert O. Bullock, Chief of Aerodynamics, AiResearch Manufacturing Co., Phoenix, Ariz. (No. 60-WA-290)

This paper reviews the evolution of the ideas that eventually led to the successful development of the transonic compressor. The significance of several broad test programs is discussed and important implications noted.

Experiences With Compressors at High Stage Load Coefficient and Mean Degree of Reaction Close to Zero, by K. E. Wichert, Chief of Product Research, Stratos Div., Fairchild Engine & Airplane Corp., Bay Shore, N. Y. (No. 60-WA-310)

In further development of the Wattendorf compressor for application in transonic and supersonic flow, some investigations have been undertaken at SNECMA, France, using a rotor wheel which had extremely high load coefficients in the blading. The paper presents details of the design and the test results. For reasons of instrumentation, the tests were limited to subsonic flow.

Aerodynamic Design and Performance of a Five-Stage, Transonic, Axial-Flow Compressor by Karl Kovach, Compressor Specialist, General Electric Co., Large Jet Engine Dept., Cincinnati, Ohio and Donald M. Sandercock, Aeronautical Research Engr., NASA, Lewis Research Center, Cleveland, Ohio. (No. 60-WA-229)

This paper covers aerodynamic design and performance of the NASA Five Stage Research Compressor. The performance aspects covered include the overall performance, detailed blade row performance and performance while operating with inlet distortion.

The J83 Seven-Stage Transonic Compressor by J. A. King, Senior Preliminary Design Engr., AiResearch Mfg. Div., The Garrett Corp., Los Angeles, Calif. (No. 60-WA-93)

The J83 turbojet engine is a high-performance, lightweight engine with a maximum thrust of 2450 pounds, a diameter of 18 inches, and a weight of approximately 300 pounds. The compressor for this engine is a seven-stage, transonic, axial-flow compressor with an inlet tip diameter of 15.2 inches and a hub-tip ratio of 0.433. Details of the aero-thermodynamic design of this compressor and the problems encountered during its development are given in this paper.

A Practical Solution to the Three Dimensional Flow Problem in Transonic Axial Flow Compressors, by Walter C. Swan, Unit Chief, Mech. Research, Transport Div., Boeing Airplane Co., Renton, Wash. (No. 60-WA-191).

This report develops a stream filament performance procedure for real fluids, including the possibility of shocks in the passage channels, wherein much use is made of compressor element statistics. Experimental comparisons with predicted theory.

Design Studies for Marine Application of Aircraft Turbine Engines by G. A. Hardgrove, Mgr., Turboshaft Engine Systems, General Electric Co., Large Jet Engine Dept., Cincinnati, Ohio (No. 60-WA-332).

This paper presents the design studies carried out in the adaptation of an aircraft turbine engine for use as a turboshaft engine in marine applications. General technical requirements and performance capabilities have been studied and the effects of a marine environment have been investigated.

Investigation of Gas Turbine as a Prime Mover in Petroleum Servicing Industry, by Don. H. Hathorn, Mgr., Mech. Research & Development Dept., and Joe K. Arnold, Development Engr., Mech. Research & Development Dept., Halliburton Co., Duncan, Okla., (No. 60-WA-292).

This paper deals with the requirements, problems, and test program to adapt a gas turbine engine to the oil well servicing industry. An excellent paper.

The MC-CYL-JET (The Multicylinder Turbojet Engine) by Robert W. Pinnes, Head, Power Plant Feasibility Branch, Systems Analysis Div., Bureau of Naval Weapons, Washington, D. C. (No. 60-WA-84).

(Continued on page 50)

Product-Technical File . .

(Continued from page 43)

On Ignition

General Laboratory Associates have several new brochures available. One covers leads and harnesses for their gas turbine ignition units; Another, entitled Research, Design and Production, outlines in detail ignition equipment manufactured by them, as well as corresponding electronic units. Equipment described is used on the latest Boeing, Douglas, Lockheed and Convair jets as well as many of the military units.

55

Lightweight Generator

Data sheets have been issued by Curtiss-Wright on their 2,000 to 30,000-rpm "multi-purpose alternator generator systems," AC or DC, direct connected to a gas turbine if desired.

56

Inco Nickel Topics

Gas turbine engineers have found I.N.T. generally carries an interesting article on gas turbine metals. Consider getting on the mailing list.

57

Turbines A Gaz Industrielles

SNECMA, one of the large French manufacturers of aircraft gas turbines, is also in the industrial gas turbine business. Detailed specifications are now available for their 100-hp unit and their 9000 to 13,000-hp unit for peak load operation. Also, their 9000 to 13,000-hp unit for continuous duty.

58

FIAT Turbines

The following is an abstract from a new brochure well illustrated covering the complete line of FIAT heavy-duty turbines.

"The FIAT gas turbine range includes four types of turbines: simple open cycle, single shaft, with one compressor and one expansion turbine, developing respectively 4100-hp, 9300-hp, 16,400-hp and 29,300-hp. The 9300-hp and 16,400-hp types are realized also in the split-shaft version with independent power turbine. All may be supplied with heat exchangers.

"The FIAT gas turbines are built with the technical co-operation of Westinghouse International Company and are entirely manufactured in the FIAT workshop."

59

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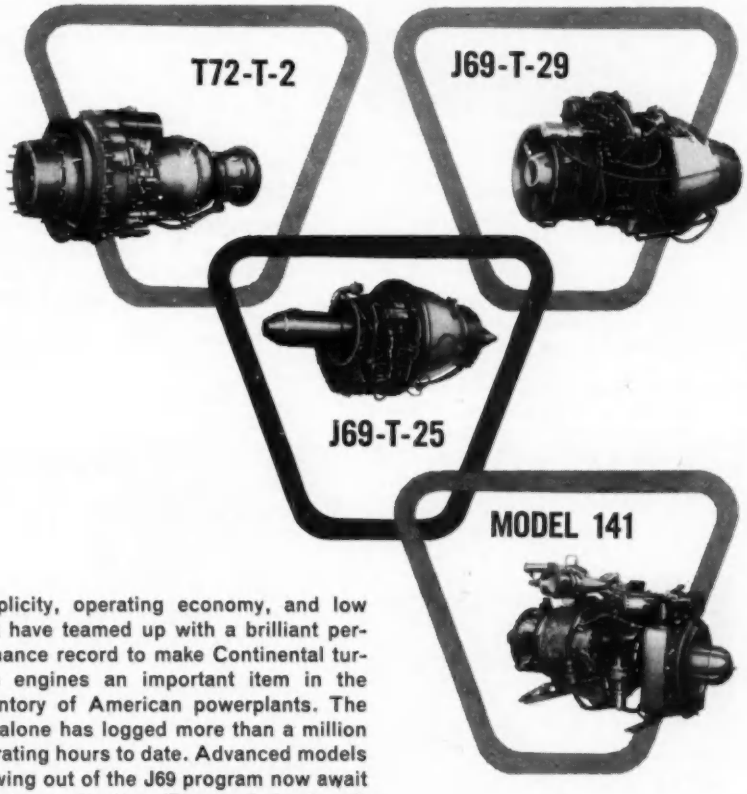

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GT PATENTS

By J. W. Sawyer

METHOD AND APPARATUS FOR PROVIDING IMPROVED COMBUSTION IN JET ENGINES (2,958,189) **4 CLAIMS** Sylvester C. Britton and Robert M. Schirmer, Bartlesville, Okla., assignors to Phillips Petroleum Company. Provides a method of operating jet propulsion type engines with a single fuel whereby higher combustion efficiency and combustion stability are obtained than was previously possible in conventional jet propulsion engines burning the same fuel. This method includes preheating the fuel to a temperature above that necessary for vaporization alone so as to at least partially decompose a portion of the fuel.

COMPRESSOR PRESSURE LIMITER FOR GAS TURBINE ENGINES (2,958,190) **8 CLAIMS** Francis R. Rogers, South Bend, Ind., assignor to The Bendix Corporation. Concerns a fuel feed and power control device for gas turbine engines and particularly to means for maintaining compressor discharge pressure or compressor rise under a predetermined maximum value.

CONTROL APPARATUS (2,958,191) **9 CLAIMS** Howard J. Williams, South Bend, Ind., assignor to The Bendix Corporation. Relates to fluid pressure responsive failure protection control apparatus.

COMBUSTOR HAVING HIGH TURBULENT MIXING FOR TURBINE-TYPE STARTER (2,930,194) **6 CLAIMS** Dana P. Perkins, New Hartford, N. Y., assignor to Bendix Aviation Corporation, Utica, N. Y., a corporation of Delaware. Improved compact combustor with reliable ignition and thorough combustion.

FLAME IGNITER FOR GAS TURBINE COMBUSTOR (2,958,196) **8 CLAIMS** Robert G. Van Wie, Fullerton, Calif., and Jacob B. Gatzmeyer, Schenectady, N. Y., assignors to General Electric Company. This invention provides an igniter for a gas turbine which is capable of serving a number of combustion chambers.

FUEL FEED AND EXHAUST NOZZLE CONTROL FOR GAS TURBINE ENGINES (2,958,186) **24 CLAIMS** Frank C. Mock, South Bend, Ind., assignor to The Bendix Corporation. Provide a control of the coordinated fuel feed and jet area type so a pilot, when he desires to accelerate or decelerate, may set his control instantly at the selected power position, and the engine will automatically accelerate or decelerate to the desired speed.

CONVERGENT-DIVERGENT NOZZLE ASSEMBLY (2,957,310) **5 CLAIMS** John Alan Courtney Hyde, Littleover, England, assignor to Orenda Engines Limited, Village of Malton, Peel, Ontario, Canada. A convergent-divergent nozzle assembly in which the break away of propulsive gas in the divergent section may be controlled to reduce thrust loss when the nozzle is not operating at its optimum pressure ratio.

TURBINE MUFFLER (2,958,506) **6 CLAIMS** Charles Chimento, Indianapolis, Ind., assignor to Silencer Manufacturing, Inc., Indianapolis, Ind. The apparatus utilizes a turbine having a free vortex type housing and a bladed rotor whose rotation serves to dissipate the energy of the engine exhaust gases.

FUEL FEED AND POWER CONTROL SYSTEMS FOR GAS TURBINE ENGINES (2,950,596) **11 CLAIMS** Elmer A. Hasse and Albert P. Schnaible, South Bend, Ind., assignors to The Bendix Corporation. Relatively simple fuel control system for gas turbine engines which will permit a substantially optimum acceleration rate throughout the entire operating range of the engine.

BLADE RETAINING MEANS (2,935,296) **6 CLAIMS** Chester E. Hockert and Leslie R. Smith, Indianapolis, Ind., assignors to General Motors Corporation, a corporation of Delaware. A simple and inexpensive blade-retaining means which efficiently secures a footed blade against movement in a disc and which facilitates removal of a damaged blade without damage to the disc.

Gas Turbine Specs

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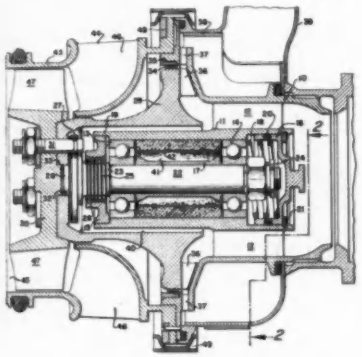
COOLING TURBINE (2,958,458) 7 CLAIMS Homer J. Wood, Sherman Oaks, Los Angeles, Calif., assignor to The Garrett Corporation, Los Angeles, Calif. Bearing cooling features: Hot, pressurized air or other gaseous fluid enters the turbine inlet housing 38 through duct 39. This hot fluid then passes through the nozzles carried by nozzle ring 37 and impinges on the cantilever blades 36 carried by the turbine wheel 29, thus causing the turbine wheel to rotate at a high velocity. The ensuing adiabatic expansion of the hot, high-pressure fluid and the absorption



of energy by the fan-loaded turbine wheel cause the fluid to be cooled rapidly. The cooled fluid, the exhaust, then passes over the vane or strut supported portion of the bearing carrier 11 which serves to keep the entire bearing carrier relatively cool. The shaft bearings 13 and 14 are cooled by heat reduction through the bearing carrier and dissipation.

SEMI - VAPORIZATION BURNER (2.959,006) 5 CLAIMS Franck Guillaume Michel Ferrie, Cachan, France, assignor to Societe Nationale d'Etude et de Construction de Moreurs d'Aviation. A burner device operating both with atomisation and vaporization of the fuel.

PROCESS FOR PRODUCING GAS TURBINE FEED (2,958,298) 5 CLAIMS Martin A. Mayers, Brooklyn, N. Y., assignor to Burns and Roe, Inc., New York, N. Y. Process for burning a finely divided solid carbonaceous fuel in the presence of air under pressure for producing such a stream.

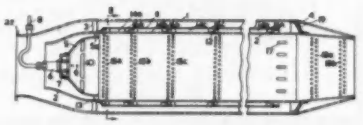
ENGINE EXHAUST APPARATUS (2,958,188) 4 CLAIMS Murray I. Leitner, Pacoima, and Johan Traksel, Reseda, Calif., assignors to Lockheed Aircraft Corporation, Burbank, Calif. Engine exhaust system for conducting engine exhaust gasses to the proper exit plane with no physical connection between the engine exhaust nozzle and the exhaust conducting tail pipe.

FUEL BURNER (2,959,003) 8 CLAIMS Denis Richard Carlisle, Risley, and Ernest Milner, Allestree, England, assignors to Rolls-Royce Limited, Derby, England. The fuel burner includes—at least a proportion of the pilot fuel spray impinges on the cowling, and the angle of divergence of the main fuel spray is such that substantially the whole of the main fuel passes through the open end of the cowling, without impinging on the cowling.

FUEL CONTROL AND IGNITION SYSTEM (2,958,377) 25 CLAIMS Gordon F. Laing, Delavan, Wis., assignor to Baso Inc., Wisconsin. Provides an improved fuel control and ignition apparatus for fluid fuel burning equipment.

MULTI - STAGE AEROFOIL BLADED COMPRESSORS (2,958,-456) 8 CLAIMS James Robert Forshaw, Farnborough, England, assignor to Power Jets Limited, London, England. Invention affords means of reducing excitation loads at the unattached ends of blades by screening the ends from the working fluid.

COOLED FLAME TUBE (2,958,194) 11 CLAIMS Frederick John Bayley, Monkseaton, England, assignor to Power Jets Limited, London, England. In operation, air enters the air casing 1 and part is divided off and enters the upstream end of the flame tube 2. Of this part of the air, some passes into the interior of the baffle 5 and also a comparatively small part of the air enters



the annular gap 13. The air thus tends to form an annular layer of cool air next to the inside of the flame tube wall, thus protecting it from the full heating effect of the hot gases.

In the November-December issue of GAS TURBINE an error was made. Patent #2,941,970 was incorrectly listed. The correct number is and should have been #2,941,790.

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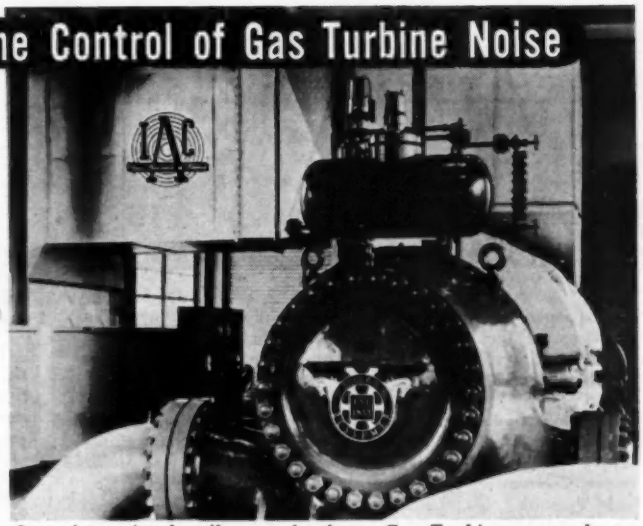

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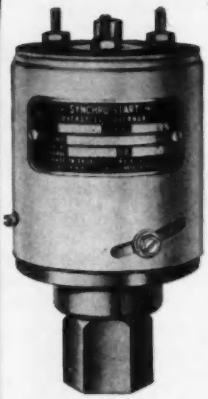

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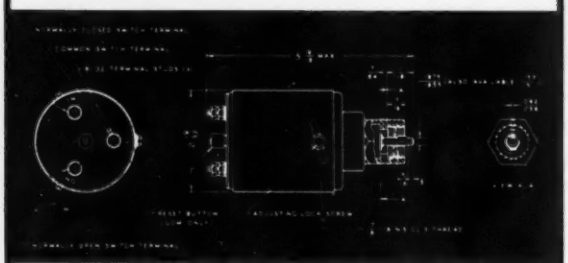

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Technical Briefs . . .

A new concept in the design of light-weight turbojet engines is presented. The general feasibility of the concept, and the overall improvements it makes possible, are discussed.

Design and Test of a Tip-Turbine Driven Lift Fan for VTOL Aircraft by A. P. Adamson, Mgr., VTOL Operation and B. H. Rowe, Systems Engr., VTOP Operation, General Electric Co., Cincinnati, Ohio (No. 60-WA-224).

This paper presents the engineering philosophy inherent in the design of the tip-turbine lift fan. Included are the results of full scale testing and application advantages of this new propulsion system.

Aerodynamic Design and Development of the General Electric CJ805-23 Aft Fan Component by Richard A. Novak, Supv., Compressor Aerodynamic Design & Development and Linwood C. Wright, Compressor Aerodynamic Specialist, General Electric Co., Flight Propulsion Div., Large Jet Engine Dept., Cincinnati, Ohio (No. 60-WA-270).

The selection, design, and development of a high performance fan for the G. E. CJ805-23 aft fan engine is discussed. Design and experimental performance are presented.

Design and Development of a Transonic Compressor for General Electric's T58 Turboshaft Engine by Morris H. Thorson, Mgr., Compressor Design Operation, Small Aircraft Engine Dept., General Electric Co., West Lynn, Mass., (No. 60-WA-171).

This paper describes the design and development history of one of the first applications of transonic compressors to production gas turbine engines. It discusses the early aerodynamic development, the aerodynamic and mechanical design, and some of the development history of this compressor.

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A Study on Design Criteria and Matching of Turbomachines—Part A: Similarity Relations and Design Criteria of Turbines (No. 60-WA-230): Part B: Compressor and Pump Performance and Matching of Turbocomponents (No. 60-WA-231) by O. E. Balje, Engineering Consultant, Hollywood, Calif.

Discussion of similarity concept for turbomachines shows the significance of the Similarity Parameters Specific Speed and Specific Diameter. Presentation of design diagrams which show maximum efficiency and optimum geometry as function of these parameters, according to the present state of the art. Discussion of application of this technique for matching of turbocomponents.

Turbocompressor Drive Couplings by James H. Anderson, Chief Engr., Machinery Products, York Div., of Borg-Warner Corp., York, Pa., (No. 60-WA-212).

This paper discusses the requirements for high-speed centrifugal compressor drive couplings, and some of the problems created by conventional couplings. It describes two new coupling designs and their advantages in meeting compressor drive requirements.

The Rotating Nozzle (HERO'S) Turbine by John F. Brady, Head, Propulsion Div., U.S. Naval Underwater Ordnance Station, Newport, R. I. (No. 60-WA-293).

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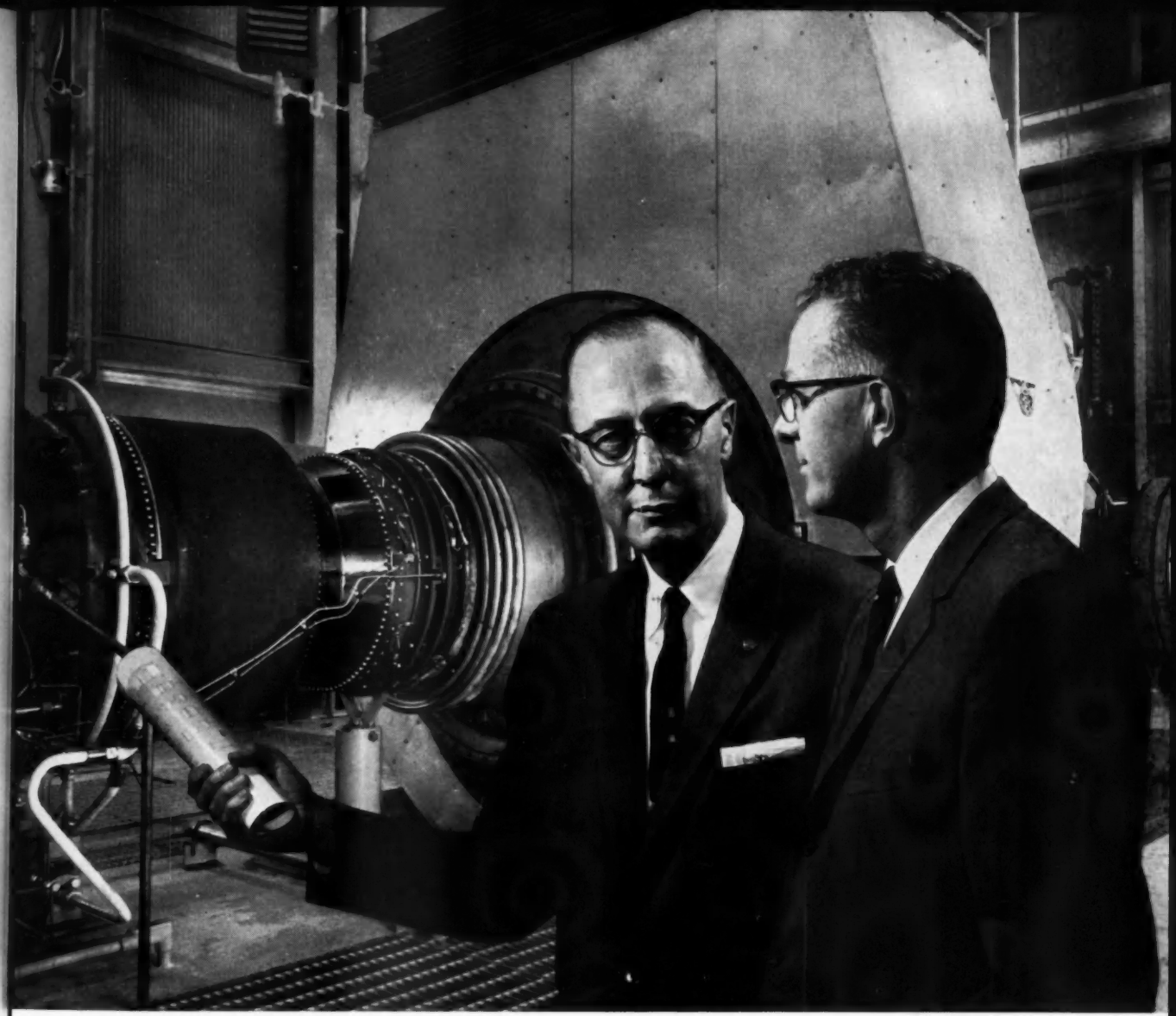

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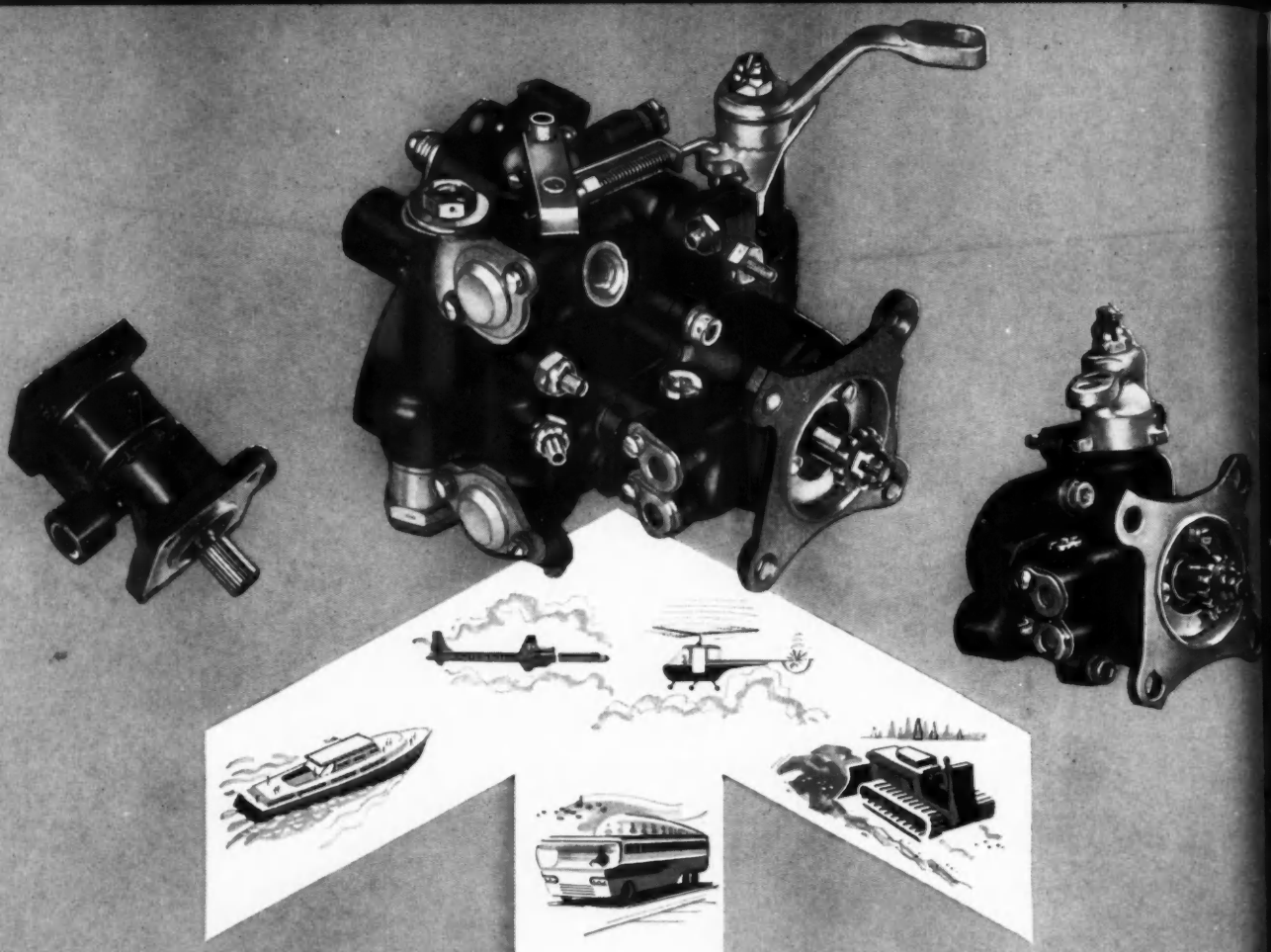

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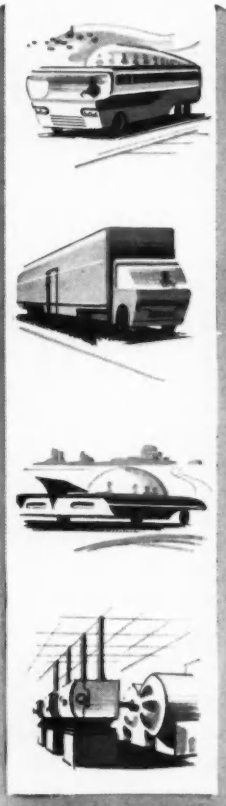

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